Tim R. New *Editor*

Insect Conservation: Past, Present and Prospects

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Editor
Tim R. New
Department of Zoology
La Trobe University
Plenty Road
Melbourne, VIC
Australia

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Preface

The field of insect conservation is alive, fertile, and growing well! But only a few decades ago, thoughts of active management programmes to conserve insects and their habitats – beyond a few butterflies and some other popular species (notably of beetles and dragonflies) – were largely utopian, and support for such enterprises scarce or non-existent. The major exception was for Britain, where conservation support could be based on demonstrations of need from a century and more of detailed natural history observations on biology and distributions, and the fauna is in general well-described and recognisable. Today, although major gaps in knowledge persist for insects in many parts of the world, insects are 'respectable' as inclusions on conservation agendas, either in their own right (as threatened species), or as wider ambassadors for environmental quality as umbrellas or flagships for wider ecologically specialised biodiversity and notable biotopes. This accelerated interest and awareness is manifest in the numbers of conservation programmes and evaluations in which insects are a primary focus, as well as the continuing series of meetings, national or international committees, and publications dealing with insect conservation. The purpose of this book is to trace and summarise aspects of the development of insect conservation interest and science. Its production was stimulated by realisation (prompted by my own formal retirement) that many of the people who have been involved in, and led, these developments had not yet summarised either their own roles or the scenarios they helped to foster and support – and that this compilation might be a useful contribution to both understanding how insect conservation has evolved and to the wider history of conservation biology. I asked a number of the major players who have guided these developments to contribute their recollections and experiences as this field has evolved, to provide a partial history of insect conservation interest, and where this might lead.

Many of the chapters have been prepared by authors who are among the 'pioneers' of the discipline, whose practical work, ideas and advocacy have helped to shape modern insect conservation practice and policy since the middle decades of the twentieth century. Others are by contemporary scientists who will carry this inheritance and modify the template for the future. Their optimism is a key contribution to the future of the world's insects, and the transition from treating the insect features of massive diversity and poor documentation as ‘impediments’ to ‘opportunities’ increasingly based on improved methods and approaches to field evaluation and data treatment, will continue to challenge our ingenuity.

Coverage is, inevitably, uneven. Parts of the northern hemisphere, where the taproots of insect conservation became firmly established, are a major focus – reflecting relatively thorough documentation of the fauna, with many hobbyist and professional entomologists contributing to a history of concern over declines and losses of insects, and the logistic and political support accorded to many aspects of practical conservation. The interest in the United Kingdom has provided pivotal guidance and is acknowledged here both in a series of chapters and in the contents of those from elsewhere. In some other places, advocates for insect conservation have for long been voices in the wilderness, but the gaps are rapidly narrowing – particularly in the temperate southern zones, with their faunas very different in character and in the amounts of basic information so far available. Tropical insect faunas still fare poorly in conservation considerations. Despite attempts to solicit essays on the neotropics, south east Asia and more of the eastern Palaearctic, in this book, these have not eventuated, so that the compilation has notable geographical gaps in coverage, as well as significant lack of tropical region perspective, and of cultural appreciations of insects and perceptions of their values. The impetus to conservation from listing many butterflies under the Indian Wildlife Protection Act, for example, is significant – but such developments cannot be appraised properly by workers outside the regions.

I am very grateful to all the participating authors and, so as not to obscure the essentially personal narratives and variety within the contributions, I have not demanded any constant content arrangement across chapters and neither edited strongly for uniformity of style or content nor queried differences in opinion or interpretation in different chapters. The detailed appraisals of the United Kingdom developments, for example, inevitably overlap in places but their perspectives are complementary. Each author (or group of authors) has discussed what they believe to be important or significant, and each is responsible for the factual content produced. In many chapters the passion and commitment of the authors is clearly evident and the collective experience summarised here is, I believe, a unique contribution to the discipline and its history. The extensive reference lists, some including elusive ‘grey literature’, provided in some essays are a record of lasting achievement.

The chapters fall into several groups, listed in the contents as ‘Parts’. The first chapter is simply an introduction to the discipline, including discussion of some of the problems insect conservation has faced during its long gestation. The major foundations from the United Kingdom and North America are summarised first, and are followed by chapters dealing with some of the southern temperate regions. Treatment of some other areas, and of broad themes follow these, and the book concludes with some ‘crystal ball gazing’ to anticipate some of the major themes that insect conservation will face in decades to come.

I am very grateful to Zuzana Bernhart at Springer for embracing the prospect of this book, and for her considerable patience over the period of its maturation. Her colleague Elisabete Machado has also provided much patient help and encouragement, and production has been facilitated immensely by the careful work of our Project Manager, Mr. Saravanan Purushothaman. Acknowledgements for photographs and other previously published material are cited in context and, whilst authors of each chapter have made every effort to trace and obtain permission for such use, the publishers will welcome notice of any inadvertent omissions. I also thank the reviewers of each chapter, some of them unknown to me because some authors sought independent comments on their essays. And, as in any multi-author cooperative work, it is a pleasure to acknowledge the readiness with which my invitation to participate was embraced by the contributing authors. Their experiences and enthusiasms are the core of the book.

Victoria, Australia T.R. New

Contents

Contributors

Jonathan B. Ball Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa

Scott Hoffman Black The Xerces Society, Portland, OR, USA

Fabio Cassola Rome, Italy

Oliver D. Cheesman Invertebrate Link (JCCBI), c/- Royal Entomological Society, The Mansion House, St Albans, UK

Betsy H. Gagné Hawaii Department of Land and Natural Resources, Natural Area Reserves System Commission, Honolulu, HI, USA

George Gibbs School of Biological Sciences, Victoria University, Wellington, New Zealand

Michelle Hamer Biosystematics Division, South African National Biodiversity Institute, Pretoria, Gauteng, South Africa

John R. Haslett Division of Zoology and Functional Anatomy, Department of Organismal Biology, University of Salzburg, Salzburg, Austria

Francis G. Howarth Hawaii Biological Survey, Bishop Museum, Honolulu, HI, USA

Minoru Ishii Entomological Laboratory, Graduate School of Life and Environmental Sciences, Osaka Prefecture University, Sakai, Osaka, Japan

Roger S. Key Carthorpe, Bedale, North Yorkshire, UK

David Lonsdale Alton, Hampshire, UK

Ian F.G. McLean Brampton, Huntingdon, Cambridgeshire, UK

Michael G. Morris Dorchester, UK

Yasuhiro Nakamura Japan Butterfly Conservation Society, Shinagawa, Tokyo, Japan

Tim R. New Department of Zoology, La Trobe University, Melbourne, VIC, Australia

David L. Pearson School of Life Sciences, Arizona State University, Tempe, AZ, USA

Robert Michael Pyle Swede Park, Gray's River, WA, USA

Michael J. Samways Department of Conservation Biology and Entomology, University of Stellenbosch, Matieland, South Africa

Matt Shardlow Buglife – The Invertebrate Conservation Trust, Peterborough, UK

Karel Spitzer Biology Centre CAS, Institute of Entomology, Ceske Budejovice, Czech Republic

Alan J.A. Stewart Department of Biology and Environmental Science, School of Life Sciences, University of Sussex, Brighton, UK

Ian Stringer Department of Conservation, Science & Research, Wellington, New Zealand

Alan Stubbs Buglife – The Invertebrate Conservation Trust, Peterborough, UK

Ruan Veldtman Applied Biodiversity Research, South African National Biodiversity Institute, Kirstenbosch Research Centre, Claremont, South Africa

Martin Warren Butterfly Conservation, Manor Yard, East Lulworth, Dorset, UK

Corinne Watts Landcare Research, Hamilton, New Zealand

Alan L. Yen Biosciences Research Division, Department of Primary Industry, Knoxfield, VIC, Australia

Chapter 1
Introduction to Insect Conservation, an Emerging Discipline

Tim R. New

1.1 Introduction

Conserving insects is still a strange concept to many people, accustomed – and, even, conditioned – to treat all 'bugs' as pests and targets for suppression or eradication, and who think of 'conservation' primarily in terms of the wellbeing of large charismatic vertebrates. Those animals, together with flowering plants, have indeed dominated conservation agendas and wider awareness of conservation need with – if they have been noted at all – tacit or expressed belief that all other organisms can be conserved under the 'umbrella' of these more popular organisms. Conservation of invertebrates continues to be somewhat secondary, but the magnitude of the threats they face, and that they do indeed need and merit more specific attention, is gradually becoming more widely apparent and accepted. 'Image problems' persist. Many insects are indeed inimicable to human interests, for example as our major competitors for crops and as vectors of disease. Many, though, are decidedly beneficial, and many of those same crops depend on pollination by insects, and the impacts of insect predators and parasitoids to help suppress the 'pests'. However, the less tangible values of insects as cultural objects, resources and vital components of sustaining ecological processes and communities in almost all terrestrial and freshwater environments are gradually being accepted more widely. Geographical and cultural gaps in perceptions of insects are important to acknowledge in considering wider conservation needs and threats – thus, the levels of wild harvesting of insects (and other invertebrates) for food in south east Asia is a dimension of 'overcollecting' almost wholly alien to western cultural perceptions (Durst et al. 2010). Likewise, in parts of China, the intensive use of some caterpillar food plants for traditional medicine is associated with declines of a number of butterfly species (Li et al. 2011).

T.R. New (✉)
Department of Zoology, La Trobe University,
Melbourne 3086, Victoria, Australia
e-mail: t.new@latrobe.edu.au

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These collective positive values have long been advocated as pragmatic rationale for conservation by biologists, but have proved rather difficult to convey to many others. Together with maturing ethical appreciation of need for conservation, and recognition that many insects have declined in abundance and distribution from human impacts on their environments, appreciations of their wider values and significance are gradually gaining more currency. As Pyle (1995) put it 'insects have become respectable in public'. Not least, as the most species-rich and ecologically varied and complex components of animal biodiversity, insects cannot be ignored in assessing impacts of the environmental changes we impose on the natural world. This chapter helps to set the scene for the book, by outlining the current scope of insect conservation and by addressing some of the general themes that have underpinned the development of insect conservation toward its current wider recognition as an important component of broader conservation agendas, as well as some of the practical difficulties they impose in doing this effectively. Essentially those difficulties are both intrinsic (such as vast numbers of species, many undescribed and undiagnosed; massive ecological variety accompanied by uneven, often poor, ecological knowledge that reflects inadequate documentation of distribution and poor understanding of population dynamics; complex life cycles, often with accessible stages present for only short periods for sampling or assessment) and extrinsic (such as inadequate taxonomic and ecological workforce, so that defining target species, assessing needs and priorities, and proscribing management are all difficult and costly; low priority amongst conservation managers; general lack of appreciation of the importance and roles of insects, and difficulties of gaining public sympathy), all of which need to be addressed.

1.2 Targets and Tools

Pyle et al. (1981) noted, in the first substantial and widely-available review of insect conservation, that the discipline was founded largely in efforts to conserve individual species of Lepidoptera (mainly butterflies) in Britain and the United States, and much further background was summarised by Pyle (1995) and recurs throughout this book, so that this emphasis and leadership is reflected here. Later developments in the southern temperate regions must draw on the benefits (and learn from the pitfalls) of northern experience and, with far fewer resources, apply these to richer, more complex and poorly known insect faunas. There, habitat (mainly biotope) conservation is the major immediate necessity. With many issues in common, approaches have necessarily sought to move beyond single-species conservation as the main initial impetus, to encompass wider conservation strategies based on communities and ecosystems: and in the tropics, the latter is acknowledged as the only practical approach to these vast and largely undocumented faunas. The 'fine filter' (species level) approach is inevitably expensive. It has massive importance in demonstrating that insect conservation can indeed work, as demonstrated particularly in northern temperate countries, but raises considerable ethical and practical problems over which species to conserve, and how to select them. In turn, some formal legislative listing of a taxon may become a passport to eligibility for the limited funding and expertise available – and views on the listing process, and the values of pursuing it, also vary widely. There will always be far more needy species, however they are selected or designated, than can be supported by individual conservation programmes. Triage is inevitable and, whereas a list of threatened insect species can be politically impressive in demonstrating concerns, and individually valuable to the species in helping to increase awareness of their plight, it may do little to increase their security or to facilitate study and understanding of their decline. The 'coarse level' (ecosystem or community level) seeks to overcome this individual selection process and expense by focus on assemblages or communities that can continue to thrive under given conditions and in particular places or biotopes. This is often in the face of conflicting demands for development for human need or welfare. The focus may be on 'diversity', but is likely also to seek 'representativeness' and 'typicalness' of the assemblages and sites and may, in addition, incorporate consideration of individual species regarded as notable in some way – perhaps as an aid to 'value-adding' in site-based triage. Both levels of concern have their strong supporters, together with their limitations and problems, but any insect cannot thrive without 'a place to live' and that place furnishing the critical resources it needs. And no insect lives in isolation, but in a community that may include hundreds to thousands of co-occurring species. Either level of focus must thereby heed the other.

One major attraction of focusing on species as conservation targets is that they are 'tangible', entities to which people can relate easily and which – despite not being as generally appealing or charismatic as many vertebrates – can receive conservation management through approaches that parallel the much more widely tested approaches and experiences with those larger animals. In practice, much practical insect conservation management at present is undertaken and/or directed by agency personnel and others versed in vertebrate biology or botany rather than by trained entomologists. The differences in scale and approach are sometimes difficult to convey. For example, many of the criteria urged for conservation status evaluation, 'risk of extinction', (such as those adopted through IUCN 2001) reflect population sizes, numerical thresholds and more predicable trends derived from 'how vertebrates work', and based on parameters such as relatively low fecundity and juvenile mortality, and relatively long life and generation times. Often, these criteria do not transfer easily to insects, in which estimating population size at any time and tracking causes of numerical change are formidably difficult. Large intergenerational fluctuations in numbers may be entirely normal, and long term monitoring may be needed to detect any genuine decline as separate from this normal numerical 'noise'. Nevertheless, objective selection of species for conservation must draw on all available biological and distributional knowledge, both for individual assessment and ranking of species for priority within the list of candidates. It is no coincidence that most insects targeted for individual conservation are members of better-known taxonomic groups. In particular, the needs of many butterflies and other attractive 'collectable' insects, for which historical information on abundance and distribution may be available, can sometimes be assessed quite accurately, and management formulated on the basis of sound ecological understanding. The British butterflies are paramount (Asher et al. 2001), as an example envied from elsewhere because of both the detail of information available and the capability and willingness to pursue practical conservation. Such detail is indeed difficult to emulate in many other parts of the world, where any conservation progress may depend on the sustained zeal of an individual or a small group of people.

Issues of scale are inescapable, and largely dictate what can be achieved. Britain is small, its insects are well-documented, it has a strong tradition of natural history and commitment to conservation, and has rather few butterflies to consider. As a contrast, Australia has more than 30 times the land area, much of it poorly explored, around seven times the number of butterfly species and numerous locally endemic subspecies (bringing the total to more than 600 taxa), insect conservation is still to be integrated fully within the national psyche, and there are few active and committed lepidopterists. More broadly, Australia has perhaps ten times as many insect species as Britain, and only about a quarter have been described formally. Going further, a major feature of much of the tropics is the exuberant richness of insect life (including butterflies) in areas subjected to massive despoliation, little priority for conservation, and few - if any – concerned resident entomologists. The major advance made for butterflies of Papua New Guinea discussed by Parsons (1999), and including a butterfly recording scheme, flowed in large part from his own residency in the country for several years from 1979. Some of the lessons pioneered, such as butterfly ranching, have led to parallels elsewhere, such as in China.

The few tropical insects ever considered for individual conservation focus include spectacular examples (such as Queen Alexandra's Birdwing, *Ornithoptera alexandrae*, in Papua New Guinea), but many local faunas are almost wholly unknown in detail. Prospects for redressing this widely are remote, but long term surveys of reserves in Peru, Costa Rica and elsewhere emphasise the very high variety and richness that may be expected more widely. Thus, the Tambopata–Candenas Reserve (Peru) has been claimed to harbour 'world record numbers' of butterfly and dragonfly species; for lesser studied groups, such claims are as yet impossible. As Lewis and Basset (2007) emphasised, simply gaining reasonably definitive inventories of tropical insects is a very complex process, losses of insect species are potentially enormous (and inestimable), and the major goal of conservation is 'to document patterns in diversity and community structure and to assess the effects of anthropogenic disturbance on the patterns'.

The above discussion emphasises developments in treating species or assemblages as 'targets', predominant foci for direct conservation. However, the wider perspective of insects as 'tools' for wider conservation assessment, for example in responses by individual species or in assemblage composition to changing environmental quality, gives them an important additional dimension in conservation. In roles such as indicators of specific changes and signals of wider human influences, some insects have become increasingly relevant in monitoring environmental management and have become important to many non-entomologists. Widened appreciation of such roles, together with awareness of the importance of insects in processes such as pollination and pest management, is an important aspect of promoting insect conservation.

1.3 The Numbers Game

Small numbers of easily recognised and well studied insect species facilitate individual species conservation assessment and management. Large numbers of species, predominantly undescribed and unstudied, hamper any such endeavour. Capability to undertake species-level insect conservation is also limited by availability of expertise and willingness to participate, as well as political acceptance (funding!) of the worth of the work. Even in the southern temperate regions, the detail available for much of the temperate northern hemisphere is not available (Stewart and New 2007) and species-focusing has given way to wider strategies - but with recognition that a complementary suite of selected individual species programmes may be invaluable in publicising insect conservation and establishing it as 'core conservation business' in political environments where the need to do this is still evident. Insect importance can be tangibly reiterated through these cases. However, with limited expertise and support, the greater collective benefits possible from habitat (whether site or biotope) and community conservation may take precedence. Lewis and Basset (2007) recognised the danger that tropical insects will be overlooked in setting conservation priorities and guiding habitat management practice - but that the major issues to face are establishing sound inventories as templates for planning and setting priorities, assessing effects of disturbance, and quantifying the roles of insects in ecosystems, in their example, in forests. Linked with all of this is the precautionary need for insect conservation in such complex environments, to conserve as much natural and near-natural land as possible (Samways 2005, 2007) and to facilitate connectivity across landscapes, with larger scale landscape diversity an umbrella for mosaic insect diversity.

The variety of priorities in insect conservation therefore spans (1) major concerns for national or more local losses of single insect species (or subspecies), perhaps from only one of several countries constituting a continental range, as in Europe to (2) almost total neglect of enormously complex tropical ecosystems that may support more insect species than the total present in any European country, as above. The massive investment of funds and effort in, for example, conservation of a butterfly in western Europe is invaluable, and the lessons learned from any such exercise may have wide practical relevance elsewhere. But it is intriguing to speculate on the possibly wider benefits for insects if equivalent funds and effort could be deployed elsewhere. In general, they cannot. Janzen's (1997) perspective for the tropics is still difficult for many biologists elsewhere to accept. One salient point is the persistent confusion between enumerating insect richness (how many species, and what are they?) and conserving them. Just as listing a species formally as threatened is not practical conservation, counting species is not conservation. Both may aid in future planning and help to garner political support, and priority may be set according to listed status or the richness of a biotope or site. Conserving rich insect faunas does not necessitate prior knowledge of whether there are several thousand or several tens of thousands of species present – and our ignorance may indeed span such an order of magnitude. As Janzen noted, we already know that there are a lot of insect species, that the biology and abundance of most of them will be almost wholly unknown, and even their identity will be obscure beyond, perhaps, having being given a number or barcode in a reference archive collection. Refining numbers within a broad range is more a byproduct of other work that may aid conservation, rather than a primary driving purpose of a survey.

Insect biodiversity is a complex set of themes to understand (Foottit and Adler 2009), but knowledge of richness and distributions helps us to delineate, interpret and understand patterns of evolution, biogeography, endemism, habitat and resource dependence, vulnerability, and 'worth' of local assemblages. As such, insect conservation draws heavily from studies of insect biodiversity, and helps to focus needs for additional work applied to setting priority for conservation amongst taxa and places. Whatever the 'biodiversity data' on insects are to be used for, information on richness of assemblages is intrinsically likely to involve various levels of taxonomic uncertainty, and voucher material of all purported taxa should routinely be archived for future reference, preferably in an institutional collection. The need for any such 'ecological collections', much of which is commonly unsorted 'bycatch' once particular study groups have been extracted, is only gradually gaining currency: in one context, for example, it is the current template against which future trend and changes can be measured. Data (most commonly as species lists, richness, relative abundance) are potentially valuable in two contexts: (1) alone, to characterise the insect fauna of a site, region, habitat, biotope or other defined study unit, and (2) comparatively, to place that fauna in some meaningful context with others, perhaps to rank it for conservation priority on grounds of species richness or representation. For either purpose, but particularly for the second context, data must be derived from similar sampling methods and effort, so that objectives of any insect survey must be very clearly planned (Samways et al. 2010) and the methods and sampling regime documented. In many cases, even studies of single insect species of conservation interest have provided misleading results because of not knowing how to look for it. The Golden Sun-moth (*Synemon plana*, Castniidae) in south eastern Australia is one such case, in which the biology and behaviour of the moth severely restricts sampling opportunity (Gibson and New 2007). Differences in approach to inventory sampling increase the chances that any given taxon may be recorded by chance rather than be equally detectable across all survey components. Although standardised approaches to sampling are advised wherever possible, it is common to have to work with whatever information is available, with little or no knowledge of how it was obtained.

All–taxon biological inventories (ATBIs) of insects from sites, particularly in the tropics are proposed widely as a model to understand global biodiversity, but are almost impossible to achieve with current levels of knowledge, support and taxonomic capability. The closest attempt in the tropics has been in Costa Rica (Janzen et al. 1993), but most such surveys have two important limitations of scale: (1) they include only a limited array of taxa, usually orders or major families, and (2) they are undertaken on small sites over a limited time, without indicating why that site or time was optimal, but simplistically because it was available. Seasonal variations in insect development and apparency are just as evident in the tropics as in more conspicuously seasonal temperate regions, and many studies have documented strong seasonal variations in insect assemblage composition (Wolda et al. 1998). For comparisons, standardisations of sampling season and method are essential to compare like with like and avoid the insect equivalents of apples and oranges!

The present limitations of ATBIs, discussed by Wheeler and Cracraft (1997), are formidable even for vertebrates, many of which also have narrow distributions, but emphasise the very limited value they may have as practical tools in insect conservation. Wheeler and Cracraft noted that major limitations are (1) the number of ATBIs needed to provide even very basic geographical coverage, and without which comparative inferences simply could not be made; (2) ATBIs are biased by the efforts made to achieve them, including those influenced by the political environment of the country in which they are undertaken, and may not be relevant unless part of a wide regional or global series; (3) collecting the organisms, however difficult and laborious this may be, is only the first (small) step in analysing the samples: 'processing' costs can be many times those of actually obtaining the material; and (4) even if samples are analysed fully we may not be able to interpret them sensibly for lack of background ecological knowledge of patterns and trophic relationships. The vastly increased global capability needed to describe and enumerate insects as an academic ideal in documenting Earth's biota, and providing information of considerable relevance in planning conservation, appears utopian. In short, it cannot be regarded as a prerequisite to conservation, its lack must not cause undue delay in conservation, and considered short cuts are needed to help overcome these interpretative limitations. Some of the supporting actions noted by Wheeler and Cracraft are directly relevant. The first three, for example, are (1) 'Provide for diverse world-wide inventorying efforts, each directed at one (or several related) taxa …'; (2) 'Increase the effectiveness of the inventorying effort and the systematic research derived from it …'; and (3) 'Establish international networks of taxonomic experts with the goal of ensuring that there is open access to expertise for every group of organisms somewhere in the world.'

Long-term studies are particularly important for inventory and this dimension may in some cases prove to be more important than spatial replications. One of few such surveys in the tropics (in Guanacaste Conservation Area, Costa Rica) suggested that almost all of a major habitat's fauna may be found at a single site if the survey is year-round over several years. Janzen et al. (1993) exemplified this by noting that a single light trap in the park will attract at least 99% of the macromoth fauna in about 5 years. Studies in British gardens over long periods have sometimes accumulated impressively high proportions of the British fauna (Owen 1991). Selecting or ranking sites for priority conservation attention may heed the richness of insects present – but, as Janzen (1997) remarked, in practice this choice may be a luxury. Little selection is possible in highly degraded tropical landscapes in which many natural vegetation associations have already been reduced to small remnant patches protected fortuitously. Some forest remnants in West Africa are 'totem forests' long protected as religious symbols, rather than for conservation purposes directly, but notwithstanding this cultural protection, loss of forests is a key threat to insects in the region (Larsen 1995). The conservation need is then to protect as many of these remnants as possible, should local priorities change. The Costa Rica surveys noted above, initiated through InBio (Reid et al. 1993), were made possible only by investment from a major international pharmaceuticals company in the context of 'bioprospecting' for chemicals. The process raises complex questions of 'ownership' of biodiversity necessitated through confidentiality agreements and other legal needs, but in less developed parts of the world (including most of the tropics) any such complex surveys cannot be supported wholly from within.

A further problem in interpreting insect numbers arises from how they are distributed. Whether all insects or any particular groups are targeted for survey, many of the species recovered will fit a common conservation perception of being 'rare', as represented by singletons or very few individuals. Increasing sample size or duration simply increases the number of rare species found. Several examples from tropical beetles are noted by New (2010): in Papua New Guinea, 119 of 418 species were represented by singletons (Allison et al. 1997); 859 morphospecies from Borneo included 499 singletons (Stork 1991); and an Amazonian survey furnished 45% of singletons in a sample of 993 species (Didham et al. 1998). Similar examples could be multiplied within Coleoptera and across many other insect orders. In short, large samples of insects from assemblages commonly imply that 'rarity' (as low abundance or, at least, low detectability) is very common. The greatest numbers of sample-rare insects occur amongst the vastly underdocumented tropical assemblages, and many are likely to become extinct before they are characterised, described, or even collected – as Centinelan extinctions. The combination of small size, unrecognized ecological importance and elusiveness ensures that many will be amongst the 'meek inheritors' (New 2000) and doomed unless their main habitats can be secured and, in many cases, managed to sustain diversity without knowing in detail what species are there. These insects will never attain the status of individual conservation targets. However, individual conservation neglect (or inability to attend them) is not confined to the small or poorly known insects. Even many better-appreciated insects, such as Afrotropical butterflies, will never merit the luxury of individual conservation programmes (Larsen 1995). But, any selection of individual targets in lesser-known groups would scarcely touch the massive collective problems they face, as Hochberg (2000) emphasised for parasitoid Hymenoptera.

1.4 Shortcuts and Surrogates

The so-called taxonomic and ecological impediments collectively reflect a massive shortfall in the expertise needed for insect biodiversity surveys, whether these are undertaken for inventory or monitoring, and conservation appraisals. Overcoming these continues to demand and trial ingenious approaches to sample collection and analysis, with the proviso that any short cut or approximation must not compromise the quality of the information obtained. Fundamental to this is clear formulation of purpose of any survey, rather than the formerly more widespread 'let's see what is there' approach to insect surveys. Comprehensive, long-term surveys based on adequate sampling sets – however desirable – are rarely possible. ‘Rapid Biodiversity Assessment’ (RBA) implicitly seeks to replace labour-intensive costly sampling regimes by less costly approaches to achieve similar results. It is attractive, but great care is needed in seeking short cuts, and assessing the limitations and uses of the data to be obtained. It is also a theme in which misunderstandings can arise easily, largely because of the different ways in which the term ‘rapid’ can be interpreted (Trueman and Cranston 1997). They noted four rather different implications, as: (1) that answers to questions on biodiversity are needed quickly; (2) that field surveys should be conducted speedily, perhaps with teams to cover different taxa at the same time; (3) that diversity measures should be made at levels above species; and (4) that species identifications for richness measures may use categories such as ‘morphospecies’ or ‘recognizable taxonomic units’ rather than formally unidentified species. The first of these tends to be emphasised by policy makers, but all raise issues of balance between expediency and scientific value.

The transition to more intensive targeted or hypothesis-testing surveys is important in use of limited resources and adding value. Thus, the aims of the Costa Rica inventory included (1) ‘tidying up’ the taxonomy of the country’s biodiversity and to get some sense of where the various taxa may be found, and (2) as a first stage in accumulating natural history information sufficient to being able to use biodiversity without destroying it (Janzen et al. 1993). The training of many ‘parataxonomists’ (more widely termed ‘biodiversity technicians’) was a key element in that programme, which has been emulated widely elsewhere to help overcome the logistic impediments of collecting and processing samples reliably.

Insect surveys have widely included two main forms of short cuts in assemblage evaluations, namely (1) to restrict the number of taxonomic groups appraised and (2) to seek focal groups that are viable indicators or surrogates for testing the particular hypothesis or idea bounding the study. Criteria for selection have been discussed extensively and, in the past, subjectivity in group selection has been widespread (Andersen 1999). However, for a variety of sound reasons, some insect groups are now commonly priorities in surveys to assess environmental condition and changes, and the future seems sure to enlarge on this approach, rather then foster impracticable ATBIs. A third tactic, superimposed on both of the above, is to reduce the level of taxonomic ‘penetration’ so that samples are sorted only to order or family level rather than to species or species equivalents. Costs of sample processing are massively reduced by avoiding the intensive examinations needed to proceed to full species details, but much information is masked or lost by this – together, in some cases, with credibility. Many commentators have noted that identification only to order or major family hides massive ecological diversity and that the categories may be so broad as to be meaningless. Different insect species differ in ecology and functional role, genetic constitution and conservation need. Spence et al. (2008) illustrated the absurdity of the approach by analogies from North American birds, suggesting that ornithologists would dismiss out-of-hand groupings such as ‘corvids’ in which ecologically very different bird species are uncritically amalgamated: treatments of beetles or moths are no different. For surveys leading to far-reaching management decisions, identification of insect samples to species level should become the standard, and more simplistic analyses discouraged. Recognising the impracticability of naming all such species, the concept of 'morphospecies' has become important in entomological surveys. Morphospecies are consistently recognisable entities deemed equivalent to full species in samples, and their use overcomes some of the problems associated with large numbers of undescribed taxa likely to be present, and allows for realistic estimates of diversity and composition within and across samples and sites. Expert advice is needed early in a sorting programme to check correspondence between morphospecies and 'real species' and to monitor sorting consistency – for example by different people (Cranston and Hillman 1992). In some specifically focused studies, sorting only to genus or species group may provide the information needed. Functional groups of ants are used widely in environmental impact studies and monitoring restoration in Australia, for example, and can be based largely on genera in this ecologically varied group (Majer et al. 2004). The universal need is simply to appreciate and understand the scientific implications of any taxonomic approximation in a survey for a given purpose, and to avoid short term expediency leading to later inadequacies.

The use of a restricted variety of insects as 'indicators' or 'umbrellas' in insect conservation is inherently appealing, with the latter intergrading with 'flagship species', as taxa of individual conservation interest whose wellbeing will enhance that of many other species in the same environments. As Pearson (1994) commented 'Rare and endangered taxa have become indicators by default because of legal processes': listing an insect species for legal protection compels notice. A conservation programme for any high profile threatened insect may, with little modification or additional effort, transform that species effectively into an umbrella. Indicators have been discussed extensively (see Pearson 1994; McGeoch 1998), and many different groups have been promoted as valuable in revealing or monitoring environmental condition or change by their trends in abundance or distribution, often by a rapid, characteristic and easily detected response. Suites of features deemed desirable in indicator insects have proliferated, but commonly include sensitivity to a given environmental change of interest, ease of sampling or other inspection and of identification (facilitating participation by non-specialists and volunteers), sufficient abundance and/or richness to detect trends of abundance or assemblage composition, sufficient biological understanding to be able to interpret (or, at least, infer) causes of changes and that these might be paralleled in other taxa, and specific or characteristic of the environment of interest. Single insect species may be used to monitor changes, as putative surrogates for wider richness, but some larger groups (such as carabid beetles, water beetles, ants) have furnished much of the background information on monitoring changes, through having been used extensively as indicators so that an array of studies is available for comparison. As two such group examples, (1) ants (above) can be captured easily in pitfall traps, so that a near-complete seasonal inventory may be obtained within a few weeks of standardised trapping, to enable reliable functional group analysis; and (2) tiger beetles (Cicindelidae or Carabidae: Cicindelinae), many of them distinctive, conspicuous and diurnal, can be surveyed by direct inspection (Cassola and Pearson 2000) so that local inventory and detection of habitat-specialist species is far more straightforward than for many other insects. Reasonably sound information on tiger beetles is available for about 157 countries or sub-regions (Cassola and Pearson 2000). Butterfly surveys also commonly involve direct visual inspection along transects (Pollard and Yates 1993): essentially, some insects are assessable much more easily than others and, should they be indicative of conditions of interest or responsive predictably to them, may be ranked highly for monitoring or establishing baseline quality in some way. Reliable taxonomy or recognition of species within any such adopted group is a distinct benefit, in communicating and coordinating results and inferences in a sound context. Groups that have been treated comprehensively in a region, with most species diagnosed and named, are likely to gain high priority, especially if a combination of user-friendly handbook and expert advice is available. Unfortunately, for most parts of the world, few such 'well-known' groups occur. They most commonly comprise butterflies, Odonata, some families of larger beetles, and much more sporadic incorporation of others, such as some Orthoptera, various aquatic insects, and some moths. Many other insect groups can be regarded as 'catch-up' groups, for which a moderate amount of taxonomic study would elevate them to well-known; and numerous others are sometimes referred to as 'black hole groups' (New 1999), with numerous species, largely undescribed and in general likely to remain for the foreseeable future within the province of the few specialists able to recognise possible species units.

The kinds of question related to environmental changes that arise in using insects in this way, and that may strongly influence the groups selected for study, include themes such as (1) is there any difference in species richness or assemblage composition over sites or times; (2) does monitoring (interval sampling) demonstrate changes in any of abundance, richness or composition and can this be related to environmental features; (3) does 'group X' show changes that are paralleled or likely to be paralleled in other groups, and thereby constitute an indicator or other surrogate; (4) how much sampling effort is needed to adequately sample the insects present and provide sound baseline data for manipulative studies; and (5) what are the effects of a given disturbance (such as fire, slashing, tree removal, grazing, or other) on richness, diversity and persistence of specialised species. One or more of these questions may be important in selecting a suitable indicator group in a particular context.

1.5 Achievements in a Developing Discipline

Many of the insect species targeted for conservation historically attained this status through perceived need for crisis management, in which site or resource security was seen to be threatened, and zeal from concerned people led to advocacy and protective measures. This point was made eloquently many years ago (Ehrlich and Ehrlich 1981), in noting (wryly!) that any major development proposed in an ecologically sensitive area is likely to lead to discovery of one or more threatened species of animal or plant on that site. Conservation was thus largely 'ad hoc' as individual needs arose, with site protection necessitating substantial political negotiation, backed up by science wherever possible. In this arena, insect conservation was viewed by many people as both novel and largely irrelevant. The decade or so before about the mid 1980s was a time of 'steep learning curves' in insect conservation: learning how to communicate effectively and promote the worth of insects, how to survey and study them and understand their needs and to evaluate the urgency of the threats present, and how to manage them. Much effort was gathering of basic data on methodology and biology. Generality across different cases was limited largely to broad principles, and design of knowledge-based management plans has been advanced substantially within the last two decades, as major steps toward wider protocols and accountability which have drawn on the increasing body of experience, both successes and errors, from the past. Thus, many recent species management plans for insects comprise logical sequences of action (New 2009), collectively encompassing all major conservation needs and in which specific objectives and actions are expressed clearly. Accompanying the increasing numbers of species whose plight is of concern, most plans include the twin interlinked major strands of 'research' (specifically targeted to clarify key knowledge gaps in the species' ecology) and 'management', increasingly with all actions phrased in SMART terms (that is, they are Specific, Measurable, Appropriate, Realistic, and Time-bound) and committed for action by named agencies or other bodies. The outcome of this transition is to increase efficiency and accountability – as well as increasing chances of successful conservation! Importantly, this step is linked with greater understanding, so that successive generations of action plans (variously termed management plans, recovery plans or other) provide cumulative knowledge for possible benefit in similar cases in the future. Many species management programmes are long-term exercises, and monitoring trends and outcomes is vital in understanding and accountability, as well as in adopting adaptive management, whereby review may lead to changes in the original protocols in response to results.

Nevertheless, urgent short term intervention may be needed in particular cases and, without it, chances for longer term conservation may disappear. Site security, for example, is a central need, and is often the most expensive and politically complex measure to achieve rapidly. Most insect conservation programmes are overseen by a 'recovery team' or similarly-titled group to coordinate and consolidate the work, and direct changes and progress. Ideally, such bodies include representatives from community groups and all other major stakeholders who may be affected, and to ensure increased knowledge and awareness of the programme.

Much innovative ecological knowledge has arisen from studies on threatened species. The historical presumption that most species occurred in closed populations has given way to realisation that many manifest some form of metapopulation structure, whereby fluctuations in incidence and abundance occur naturally, together with local extinctions. Studies on butterflies, in particular (see Ehrlich and Hanski 2004), have helped to show that local extinctions in patchy environments may not necessarily be unusual or matters for concern, but have also demonstrated forcefully that landscape considerations, rather than conditions of single sites alone, are of central relevance to insect species conservation. This appreciation has far-reaching implications for insect conservation, and emphasises the importance of connectivity and networks (Samways 2007) to insects, together with clear understanding of their dispersal prowess and patterns of movement and resource use. Insect conservation is receiving increasing attention in arenas that can do much to consolidate landscape values. Agroecosystems are a prime example (New 2005), in which insect conservation can demonstrably contribute to effective crop production and is integral to practices such as conservation biological control, whereby concentration on native predators and parasitoids of crop pests avoids the possible problems of introducing alien classical biological control agents. Greater appreciation of the subtleties of resource needs has been accompanied by definitions of critical resources as both consumables and utilities (Dennis et al. 2006) as a central concept of the 'habitat' of an insect, as well as transition from conservation of the focal species alone to the module of interacting species of which it is part. These subtleties help to endorse the complexity of much insect conservation management, and that it is not sufficient in most cases simply to 'lock up' a site: proactive management to control threats is almost always necessary, commonly over many years, and often to sustain site suitability through controlling plant successions.

The scope of insect conservation includes both in situ and ex situ components, with the popularity of 'butterfly houses' and similar exhibits from the1980s onward (Collins 1987) an important vehicle in increasing awareness of insects and a conduit to conservation breeding. Wider 'invertebrate exhibits' are not uncommon, and some zoos have taken major leads in captive breeding programmes, accompanied by informative signage for visitors, for threatened insects. That for the Lord Howe Island Stick Insect (*Dryococelus australis*) in Melbourne (Honan 2008), for example, has been instrumental in preventing extinction of this species. As in other conservation aspects, much general husbandry information is now available as a basis for breeding any previously unstudied species for which needs arise, and the modern ethos of many zoos (namely, as 'arks' for conservation, rather than novel exhibition alone) has extended increasingly to participation in invertebrate programmes, with detailed record keeping to track and counter possible genetic deterioration in captivity.

1.6 Spreading the Word

In common with much other conservation practice, much of the background information in many relevant cases for insects remains in informal or institutional reports or the 'grey literature' of very limited distribution. Much of this can be traced through the world wide web, but the growing body of peer-reviewed scientific publication is a major contributor to furthering interest. Especially from the 1980s on, papers on insect conservation appeared increasingly in leading journals such as Biological Conservation and Conservation Biology (with the first volume of the latter including E.O. Wilson's famous call for invertebrate interests as 'The little things that run the world': Wilson 1987, perhaps the single most well-known and frequently cited stimulus for development of practical conservation interest). These journals served to bring invertebrate issues to attention of many conservation biologists who would otherwise not consider insects, together with many pertinent practical ecological studies published in other journals. Formation of a more specialist outlet was debated extensively in the mid 1990s, leading to the appearance of the 'Journal of Insect Conservation' from1997. Two major concerns at that time were (1) whether there was enough demand and publishable material to support this enterprise and (2) whether it was otherwise premature in 'preaching to the converted' and perhaps drawing papers otherwise published in the above journals where they would be encountered by potential 'new converts'. The journal has progressively gained international recognition, and helped to foster publication of material (including a number of thematic 'special issues') aiding acknowledgement of insect conservation in the mainstream of conservation biology. The Royal Entomological Society established 'Insect Conservation and Diversity' from 2008, and increasing numbers of other journals now carry insect conservation papers, with numbers of contributions continuing to increase in the variety of taxa, topics and geographical coverage treated.

Many entomological and wider natural history societies now include conservation as a major theme. Other groups have a primary conservation purpose: some of the leading bodies, such as the Xerces Society (North America), Butterfly Conservation (initially UK, now extended through Europe) and Buglife –the Invertebrate Conservation Trust (UK) are discussed in this volume as amongst the leading proponents and publicists, but many Entomological Societies have conservation sections or committees focusing on issues at scales from regional to international. Within the World Conservation Union, a number of insect-based Specialist Groups within the Species Survival Commission (SSC) operated in the late 1980s-early 1990s, dealing with Lepidoptera, Odonata, Orthopteroid insects, social insects, and water beetles. Each such group had broad international constitution and, under the goals of the SSC, was charged with providing leadership in (1) assessing conservation priorities for species and their habitats; (2) developing plans for their conservation; (3) initiating actions needed for the survival of species; and (4) providing an expert resource network on the conservation of biodiversity. In practice, the major tasks were to establish priorities and work towards communicating these effectively and for tangible conservation benefit. After a hiatus of some years, a series of newly-formed specialist groups (for insects being for butterflies, bumblebees, dragonflies, grasshoppers) have recently resumed activity. Major early outputs through IUCN included the 'Invertebrate Red Data Book' (Wells et al. 1983, a major synthesis of invertebrate conservation needs, including much on arthropods), followed by a global focus of one of the most charismatic groups of insects, swallowtail butterflies (Collins and Morris 1985), both compendia of enduring significance and value. Specialist group outputs included global action plans for swallowtails, following from the above book (New and Collins 1992) and Odonata (Moore 1997), and an overview of conservation needs of the largest family of butterflies, Lycaenidae (New 1993). A number of internal working documents also helped clearer focus on insect problems. Each of these publications tended to highlight species that, for some reason, were deemed of high conservation priority. Some were drawn from previous listings or legislation, and others were novel and subsequently elevated for more formal protection.

IUCN has also produced a global Red List of Threatened Species, which continues to be prominent in guiding conservation activities, and gives rankings of threat for species based on a given set of criteria helping to evaluate risk of extinction. The most recently modified criteria (IUCN 2001) contain some, such as quantified thresholds based on populations sizes that are largely impracticable for most insects, and extensive debate has occurred over how these may be applied. The list has been updated at intervals since it appeared initially in 1984, with the more formal criteria introduced from 1994. Although inevitably very incomplete for insects, listing of a species on this list accords it global significance and is an inducement to heed its wellbeing.

More locally, many insects brought to wider attention through IUCN activities have been signaled in national or regional protective legislation, with formal recognition at both global and lower levels facilitating support. However, with very few exceptions, any such listing or protected species schedule for insects is indicative rather than comprehensive. However, in practice, 'listing' may be a 'visa' to eligibility for limited funding support and thereby a component of selection for priority: many equally deserving but unlisted species are then simply unable to be supported.

Linked with species designations in advisory or legally binding schedules has been increasing attention to defining threats and how these may be mitigated as the key aspect of management. The varieties of contemporary threats – dominated by issues of habitat and resource loss, quality and access, the impacts of invasive species and (for some insects) questions of impacts of over-collecting – are now complemented universally by largely imponderable considerations of impacts of climate change. Despite uncertainties over detail and rates of change, the reality of climatic influences seems inescapable and changing temperature and precipitation regimes certain to influence the well being and distribution of many, even most, insect species. Those most at risk are believed to include ecological specialists and those living in environments from which escape in space is unlikely to occur – such as insects already in high alpine zones, believed to be restricted there by temperature and resource needs, and for which the most obvious trend would be to move upward as conditions become warmer – presuming, of course, that there is any 'up' left to colonise!. Planning conservation for the numerous insects likely to undergo range changes emphasizes the needs for long term consideration and also the inadequacy of focusing solely on currently-occupied sites. Change from primary considerations of current site-based conservation to landscape issues to incorporate future ranges, where such range changes may be possible, necessitates much wider thinking than is usual at present. Development of interest in both the practices and policy for effective insect conservation continues to provide serious challenges on how best to move forward. The work outlined in this book illustrates how the necessary foundations have been constructed, and some of the outcomes achieved so far.

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Part I
Organisations in the United Kingdom

Chapter 2
Insect Conservation in the United Kingdom – The Role of the Joint Committee for the Conservation of British Insects and Invertebrate Link (JCCBI)

Michael G. Morris and Oliver D. Cheesman

2.1 Introduction

Invertebrate Link (JCCBI) is a forum for voluntary and professional organisations involved in the conservation and study of invertebrates in the UK. There are currently 36 member organisations, including the leading conservation bodies, entomological societies and statutory agencies (see Table 2.1). The objective is to *'advance the conservation of invertebrates in the UK by facilitating exchange of information between relevant organisations and statutory bodies, and by providing a context for co-operative ventures in relation to the development of strategy, policy, principles and best practice'*. The history (and prehistory) of this umbrella and co-ordinating body is a long one, and reflects changes in approaches to conservation, particularly of insects and other invertebrates, over many years.

Compared with vertebrates, especially birds, and vascular plants, insects and invertebrates generally have been a minority concern for conservationists historically. The reasons for this are well known, but a brief consideration of them may help to put the history of Invertebrate Link (JCCBI) and its predecessor bodies in context. In most cases, insects are small and inconspicuous. They are not furry, feathery or cuddly. Nor are they stationary in the environment as are plants and fungi. The few British butterflies attract interest and attention and have been considered to be 'honorary vertebrates' by some conservationists. Moths, dragonflies and orthopterans have also attracted greater attention recently, in part because of the influence of digital photography as a potential method of recording. However, most insects still defy the attention of most conservationists. Above all, there is the 'taxonomic impediment', by which is meant the difficulty of identifying and naming any

M.G. Morris (✉)
Orchard House, 7 Clarence Road, Dorchester, DT1, 2HF, UK
e-mail: mgmorris.ent@virgin.net

O.D. Cheesman
Invertebrate Link (JCCBI), c/o Royal Entomological Society, The Mansion House,
Chiswell Green Lane, St Albans AL2 3NS, UK

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Table 2.1 Invertebrate Link (JCCBI) Member Organisations as at January 2011

Amateur Entomologists' Society
Ancient Tree Forum
Aquatic Coleoptera Conservation Trust
Bees, Wasps & Ants Recording Society
Biological Records Centre
British & Irish Association of Zoos & Aquariums (Terrestrial Invertebrates Working Group)
British Arachnological Society
British Dragonfly Society
British Entomological & Natural History Society
British Myriapod & Isopod Group
Buglife – The Invertebrate Conservation Trust
Butterfly Conservation
Conchological Society of Great Britain & Ireland
Countryside Council for Wales
Dipterists' Forum
Environment Agency
Field Studies Council
Forestry Commission
Freshwater Biological Association
Joint Nature Conservation Committee
Linnean Society
Malacological Society
National Biodiversity Network Trust
National Museums of Scotland
National Trust
Natural England
Northern Ireland Environment Agency
Natural History Museum
Oxford University Museum of Natural History
People's Trust for Endangered Species
Riverfly Partnership
Royal Entomological Society
Royal Horticultural Society
Royal Society for the Protection of Birds
Scottish Natural Heritage
Wildlife Trusts

insect by anyone who is not an expert entomologist. Even then, there are few entomologists with an encyclopaedic knowledge of all orders, even of the relatively small number of species in Britain (c.25,000 insects *s. str.*). Although many insects can be identified in the field by an expert, many others need to be collected, and often killed and 'prepared' for accurate determination to be made.

Emphasis in the past has been on forming collections, and this activity remains important for many professional and amateur entomologists. 'Collection development' is one of the most important activities for major museums of natural history.

The prevalence and popularity of 'recording schemes', to identify the distributions of species at a relatively fine scale has, on the one hand, reduced making a collection as a primary activity but, on the other, put a premium on accurate determination and the maintenance of voucher specimens. A recent newspaper article described collecting insects, pejoratively, as a 'Victorian activity'; however, conservationists of the calibre of David Attenborough and Gerald Durrell have emphasised the importance of young people making collections if they are to get fully involved in natural history. The trite admonition 'Take nothing but photographs, leave nothing but footprints, kill nothing but time', seen on many a nature reserve's noticeboard, betrays a superficial approach that is entirely inappropriate for insect conservation (Max Barclay, blog 26 June 2010).

Throughout this account the mutual dependence and synergy of entomological science, involving the collection of specimens, with insect conservation, will be emphasised. It has been a fundamental tenet of Invertebrate Link (JCCBI) throughout its history. 'The advance of both conservation and entomology depends on a mutual confidence between conservationists and entomologists, with an awareness of each other's legitimate concerns and aspirations and a desire to find common ground' (Morris 1976). See also Chap. 4 in New (2010).

2.2 Beginnings and Fore-Runners

As early as 1896, the Council of the Entomological Society of London (from 1933, the Royal Entomological Society, RES) appointed a committee to consider the protection of British insects in danger of extinction; indeed, it is likely that concerns within the Society developed rather earlier, as internal procedures would likely have made the establishment of a committee a rather lengthy process (Collins et al. 1988). It has proved difficult to ascertain from the Society's records the members of this pioneering committee, though the well-known lepidopterist C. G. Barrett was appointed secretary, nor to discover the work that the committee undertook. It seems certain that the main concerns were species of butterflies and that the perceived danger was over-collecting. It is recorded that, at a meeting of the Society on 7 April 1897, 'many' Fellows signed a statement to the effect that they would not indulge in over-collecting, thereby setting an example to others. It has to be remembered that at this time the subject of economic entomology was in its infancy; most Fellows of the Society were amateurs or academics. The impact of human activity on the countryside and natural populations of animals and plants was also hardly appreciated. The pages of Tansley (1939), for example, make little reference to such influences, concentrating on climatic, geological and pedological ones, though the importance of biotic pressures, such as rabbit activity, was documented.

One habitat type that was clearly recognised at this time, or even earlier, as having been greatly affected by human activity was fenland. It is no coincidence that entomologists, either actively or incidentally, were instrumental in promoting the conservation of the two most famous East Anglian fenland reserves – Wicken and Woodwalton. Wicken was well-known at the time as an important site for what would nowadays be called biodiversity, especially for insects (Rowell 1997). In particular, Wicken was known for the Swallowtail (*Papilio machaon*) and Woodwalton for the Large Copper (*Lycaena dispar*) (the Swallowtail was never found at Woodwalton though known from Whittlesea Mere, near Woodwalton, before it was drained in 1848 (Omer-Cooper 1926)). Both species were undoubtedly among those giving concern to the Entomological Society's Council in the late 1890s, although the Large Copper was recognised as being extinct by this time.

Thus entomological importance contributed to the reasons for the National Trust's acquisition of parts of Wicken Fen in 1899. It is perhaps ironic and an example of changing emphasis at Wicken that whereas the earlier *Natural History of Wicken Fen* (Gardiner 1923–1932) included 20 accounts of insects (none on birds!) the more recent *Wicken Fen* (Friday 1997) included only one multi-author chapter on insects (with four on birds!). It is true that a faunal checklist (Friday and Harley 2000) supplemented the 1997 publication, but it is not an annotated account compared with the earlier contributions in Gardiner, which have much more detailed information. A largely negative effect of entomologists (or an entomologist) is that it is known, or at least thought, that a potentially damaging fire on Wicken Sedge Fen in 1929 (Godwin 1932) was started by the famous coleopterist Dr David Sharp.

Woodwalton Fen was acquired by the Society for Promotion of Nature Reserves (SPNR) in 1919. The Society included several prominent entomologists, most notably Hon. N. C. Rothschild. Management of the Fen later passed to the Nature Conservancy, while the SPNR became, in the fullness of time, the parent (or perhaps step-parent) of the country's Wildlife Trusts. Woodwalton was famous for its colony of Large Copper (*Lycaena dispar*), but this reintroduced butterfly could flourish only under artificial conditions (Duffey 1977). Entomological research had a less comprehensive record at Woodwalton than at Wicken, though entomological activity was considerable, with several accounts of major groups being produced, e.g. Buck (1962) on the Coleoptera, Morris and Dolling (1969) on Heteroptera and Morris (1969) on aquatic Heteroptera, mainly Corixidae. Duffey (1971) published an account of the management of the Fen.

Naturally, entomological activity, and rudimentary concern for insect conservation, was not confined to the East Anglian fens, but their history demonstrates that entomology influenced developing approaches to nature conservation more broadly. Thus the stage was set, so to speak, for a more formal approach to insect conservation in Britain. This duly occurred. The Entomological Society of London established a Committee for the Protection of British Lepidoptera (CPBL) in 1925. However, even at this early period, tensions between the committee and the Society's Council were apparent and the committee was not formalised as a Committee of Council until 1931.

2.3 The RES Conservation Committee, 1931–1968

As far as species were concerned, the CPBL's priorities were the British butterflies, particularly the Large Blue (*Maculinea arion*). However, the actions taken in the name of conservation were very different from those that would be considered appropriate today. It is recorded that a visit was made to North Cornwall to purchase a site on which the butterfly flew. With the benefit of hindsight, it is easy to criticise such an approach, taken without knowledge of the particular requirements of the butterfly (Thomas 1991).

The early minute books of the CPBL illustrate the simplicity of its approach to conservation. There were no official bodies with which to cooperate or liaise, no statutory legislation to be observed, no other interests to be considered, no other societies to involve, and virtually no body of conservation research or survey on which to base decisions. Nevertheless, the Committee met regularly from 25 September 1925 until 19 May 1939. Some valuable work was done under its Chairman, Lord Rothschild (Collins et al. 1988). With the coming of World War II, there was a gap, but the Committee met on 4 December 1942 and once a year from then onwards. However, it is not surprising that little practical work was achieved during the war years.

From 26 February 1948, the CPBL was reconstituted as the Committee for the Protection of British Insects (CPBI), thus widening its concerns from just Lepidoptera (and mainly butterflies) to the whole of the British insect fauna. In 1955, a minute records that the RES Council agreed to the CPBI remaining unaltered ‘for another year’, perhaps the first signs of the difficulties leading to the formation of the JCCBI.

At about this time, the influence of the Nature Conservancy (set up under the National Parks and Access to the Countryside Act, 1949) began to be felt. Up to this time, too, the minutes of the CPBI were hand-written. The first typed minutes (8 January 1958) were notable in that they recorded the appointment of Dr Norman Moore to the Committee. However, with the establishment by the Nature Conservancy of its Entomological Liaison Committee in that year, it would appear that representation of its officers on the RES Committee ceased. Nevertheless, there was a good deal of co-operation, or at least mutual recognition, between these two committees, with some consideration of each others’ agendas. The establishment of a surveys grant scheme by Shell at about this time was a sign of future support for practical conservation activity.

It is clear from the minutes of the CPBI that its concerns and interests were growing. At the same time, there was a good deal of informality about the Committee’s meetings. For example, T. R. E. Southwood, the most prestigious of the Committee’s chairmen, was noted as ‘also present’ at the meeting on 12 February 1962, with no evidence that he was elected. However, at the next meeting (22 October 1963) he was in the Chair, again with no minute recording his election or appointment.

As might have been expected, the appointment (however informal) of Dick Southwood as Chairman quickened the pace of the CPBI’s activity. It is widely accepted that the issue of organochlorine insecticides was the *casus belli* for controversy between the Committee and the RES Council. Among members of the latter were medical and agricultural entomologists who, in some respects quite rightly, regarded DDT and the other organochlorines as wholly beneficial to humankind, and for whom eggshell-thinning in a few bird species was inconsequential. That was certainly how Collins et al. (1988), and more generally Morris (1987), saw the issue. Interestingly, however, the Committee’s minute books make no mention of this controversy, but tell a different story. At its meeting on 2 February 1967, it was recorded that Council 'referred back' a proposal from the CPBI that Fellows should give entomological information to County Naturalists' Trusts (the future Wildlife Trusts). It is possible, of course, that this seemingly uncontroversial issue was cover for the more serious business of organochlorine pesticides affecting the wider countryside.

Be that as it may, the RES Council resolved on changing the way it supported conservation. A meeting on 21 June 1968 was called to establish a joint committee for insect conservation, a move which accompanied the dissolution of the RES Committee and the Nature Conservancy's Entomological Liaison Committee. A provisional joint committee was set up under the Chairmanship, first of H. L.G. Stroyan (for the Society), and then of N. D. Riley (for the new, independent Committee). The first meeting of the new Joint Committee for the Conservation of British Insects (JCCBI) was held on 1 November 1968.

2.4 From Joint Committee to Invertebrate Link (JCCBI)

The concept of a joint committee was all very well, but it was soon apparent that, 40 years ago, the number of national entomological societies in Britain was limited. The first partners alongside RES were the Amateur Entomologists' Society (AES), the British Entomological and Natural History Society (BENHS), the British Trust for Entomology (now defunct) and the British Butterfly Conservation Society (now Butterfly Conservation); these were subsequently joined by the Entomological Suppliers' Association (now defunct), and later by the Balfour-Browne Club and the British Dragonfly Society (Collins et al. 1988). The earliest participants also included a representative of the Keeper of Entomology at the British Museum (Natural History) and an observer from the Forestry Commission; the Nature Conservancy and the SPNR were also represented.

In order to give some publicity to the Committee and its activities, its Terms of Reference were published (including as JCCBI 1969, 1970a, 1970b, 1970c). To provide country-wide support, a system of regional representatives was put in place, with some initial success, despite the difficulties of such members (from Scotland, Wales and Northern England, etc.) attending meetings in London. This was always the venue for the Committee's meetings, since the terms of the JCCBI's existence included full administrative support from the RES. At this time, Miss Elizabeth Inglis, a member of the Society's staff, took on the role of the Committee's 'Clerk', providing a presence for it at 41 Queen's Gate, a postal service, and continuity between meetings. The relationship between the Society and the JCCBI owed a great deal to Miss Inglis's interest and activity (despite her crippling arthritis), until her death in 1981, and declined somewhat thereafter. However, the focus of conservation in the RES was 'mainly through the activities of the Joint Committee for the Conservation of British Insects' (Dempster 1991). It would be some years before the Society became directly engaged in the field, for example, through a Conservation Special Interest Group, re-establishment of its own Conservation Committee, and

Table 2.2 JCCBI / Invertebrate Link (JCCBI) Officers

Honorary President
Michael Morris (1991–present)
Chairman
Norman Riley (1968–1976)
Kenneth Mellanby (1976–1991)
Paul Whalley (1991–1994)
Elected to chair individual meetings (1995–2000):
David Lonsdale
Alan Stubbs
Stephen Miles
David Nellist
Keith Alexander
Raymond Uffen
Martin Willing
Nigel Bourn
Brian Eversham
Oliver Cheesman
Oliver Cheesman (2000-present)
Secretary
Michael Morris (1968–1991)
Conservation Officer [paid role]
Helen Smith (1990–1993)
Surveys Officer
Jeremy Thomas (1978–1982)
Martin Warren (1982–1990)
Paul Waring (1990–2000)

administration of the Marsh Awards for Insect Conservation (Stewart 2001, 2006). The two international symposia on insect conservation organised by the Society (Collins and Thomas 1991; Stewart et al. 2007) also deserve to be acknowledged.

Despite the generous administrative support supplied by the RES, JCCBI had no sources of revenue itself. The Committee has remained a primarily voluntary body, principally reliant on the unpaid efforts of elected officers (see Table 2.2), member organisation representatives (Fig. 2.2) and (from 1985) a small Executive sub-committee. Its member organisation representatives either attend twice-yearly meetings at their own expense, or do so within the remit of their employers or societies. Modest financial support has been received occasionally, for example, to support survey work or conferences (see below). The Job Creation schemes and Manpower Services initiative enabled JCCBI to employ young people for periods of 40 weeks to undertake administrative and survey tasks in the 1970s and 1980s. Core support was provided briefly by WWF in the early 1990s, following a successful appraisal of the Committee and its work. Agreement was reached with the World Conservation Monitoring Centre (WCMC) for a shared administrative post, to be stationed at the Centre's Cambridge offices. Helen Smith was appointed for 3 years in August 1990.

Although much good was achieved through having a permanent post-holder, one of the main tasks that Miss Smith attempted, the provision of on-going core-funding for the Committee, proved ultimately unsuccessful. So, after a short period of having paid staff, JCCBI had to revert to its more usual position of being run by volunteers. Although not formally recorded in the Committee's minutes, sometime in 1992 the name was changed from Joint Committee for the Conservation of British Insects to Joint Committee for the Conservation of British Invertebrates. This broadening of scope strengthened the Committee by extending the membership to bodies concerned with other taxa, whilst conveniently retaining the 'JCCBI' acronym. At around the same time, the system of regional representatives was abandoned, as the member organisation representatives themselves now covered a wider geographic area, and observers from the new country conservation agencies began to attend meetings.

Late in 1993, amid concerns about the ability of the Committee to operate without at least a small, paid staff, and questions over whether it was effective or even needed, JCCBI was nearly disbanded by its then membership. However, the Committee received what was, in effect, a vote of confidence. It is interesting to note that suggestions for the reinvigoration of the Committee included a change of name to 'Buglife'; instead, it was agreed to seek renewed support from RES.

At an early stage, the Committee adopted a distinction between member organisations and those (particularly statutory bodies) that were represented at its meetings as observers. The best means of engagement with statutory organisations is always an issue for umbrella bodies for, or networks of, NGOs. Wildlife and Countryside Link, for example, excludes statutory organisations from its membership, and readily develops collective NGO views that are critical of Government, and lobbies on policy in a vigorous and highly visible manner. JCCBI gradually moved towards an alternative model, where statutory bodies were part of the membership ('inside the tent', as some might see it), and engaged directly in the Committee's discussions. To this end, the distinction between member and observer bodies, which had become increasingly blurred, was formally ended by JCCBI in 2000. At the same meeting, the Committee agreed to change its name again, to 'Invertebrate Link (JCCBI)', thereby retaining the acronym by which it was widely known, but emphasising its role as a networking body. (However, the shortened form 'Invlink' is often used for convenience, as here). A further broadening of the membership followed, and has gradually continued.

New Terms of Reference were prepared in 2001, and integrated in 2003 into a broader statement of Roles and Responsibilities. This internal document was modified somewhat for publication in Cheesman and Phillips (2004), where there is some emphasis on distinguishing the respective roles of InvLink and Buglife (which had recently been established – see below). In essence, InvLink would remain a forum for the development of collective views, concentrating on issues relating to strategy, policy and the promotion of appropriate principles and best practice. Buglife, having the facilities to manage specific, funded projects, and with a full-time staff, would be better placed than InvLink to implement conservation action 'on the ground', undertake public campaigning, and respond rapidly to particular incidents or circumstances.

With the move of RES from Queen's Gate to St Albans in 2007, InvLink needed to find a new London base, and currently meets at the NHM or the Linnean Society. However, RES continues to provide a postal address for the Committee, and hosts the InvLink webpage (http://www.royensoc.co.uk/InvLink/Index.html).

Particular areas in which the Committee has been active are considered under appropriate headings in the following sections. However, reading through the minutes of JCCBI and InvLink meetings, one is struck by the wide variety of issues and events that have been considered and experienced, and of which only a select few can be reported here. Species declines and extinctions, such as those of the Essex Emerald moth (*Thetidia smaragdaria*) were a constant theme, as were various concerns about over-collecting on the one hand, and over-regulation of permissions and permits on the other. Throughout the 1970s and 1980s, the influence of wildlife conservation grew, both nationally and internationally. JCCBI maintained contact with wider networks of environmental organisations, as best it could, through bodies such as IUCN and the Council for Nature. In some ways, the demise of the Council for Nature in 1980 came as a relief to those members representing JCCBI at its meetings. They faced continual sniping from the better-endowed bodies (particularly those concerned with bird conservation) over the inability of the entomological community to match the financial contributions of other organisations. There was little recognition of the different scale of interest of the general public in invertebrates as opposed to vertebrates, a distinction which, of course, is still with us today. Despite these challenges, JCCBI remained engaged with wider networks of NGOs, being amongst the founder members of Wildlife Link (Collins et al. 1988) which, in some respects, took over from the Council for Nature. JCCBI remained involved with this network when it later became Wildlife and Countryside Link, but withdrew in 1995 and has never rejoined, principally owing to a lack of funds and personnel. The Washington Agreement, leading to CITES, was formulated in 1977, and although the Committee had little role in international insect conservation it was inevitably drawn in to discussions and debate on international issues. The Committee also enjoyed useful communication with the Xerces Society in USA, with one of its leading butterfly conservationists, Dr Bob Pyle, attending meetings when in UK.

A positive trend since JCCBI was established has been the rise of those societies, recording schemes and groups concerned with particular invertebrate taxa, and the greater interest being taken by national societies in conservation. With the notable and regrettable exception of Coleoptera, most orders of British insects now have their interest groups, and many have joined the ranks of InvLink's membership. The AES and BENHS, both of which had effective and active (if somewhat few) workers for conservation, began to take a much more positive attitude towards its importance. Concurrently, there seems to have been continual change in the official bodies charged with wildlife conservation, for example, with the establishment of the Natural Environment Research Council (1965), the 'split' of the Nature Conservancy (1973), the division of the Nature Conservancy Council (NCC) into the country agencies (1990), the transformation of English Nature into Natural England (2006) and, mostly recently, an increasing devolution of activities from UK to country level. This last trend presents a challenge to small NGOs, which invariably lack the resources to engage separately with administrations and official bodies in England, Wales, Scotland and Northern Ireland.

It is fitting, in this paper, to pay tribute to four outstanding entomologists who were instrumental in forming the JCCBI and guiding its activities in its formative and developing years. Although not formally a Chairman, Dick Southwood had an important role in setting up the JCCBI and took a continuing interest in its activities despite a busy and high-profile public life (Morris 2007). The first Chairman of the Committee, Norman Riley, brought to its meetings his wisdom and experience as Keeper of Entomology at the NHM and professional interest in butterflies. He was succeeded by Kenneth Mellanby, who had a high profile as a conservationist and first Director of Monks Wood (now sadly no more). He in his turn was succeeded by Paul Whalley, who saw the Committee through the expansion of its coverage from insects to invertebrates. Other stalwarts and supporters of JCCBI who deserve particular recognition include David Lonsdale, who (amongst other tireless work for the Committee) has invariably led the effort on drafting and re-drafting of codes and other outputs for many years. Alan Stubbs should be acknowledged also for his long involvement with JCCBI, including as organiser of its first four conferences (see below), in addition to his earlier work with the Committee.

2.5 The 'Code for Insect Collecting'

As early as its second meeting, on 2 April 1969, JCCBI considered producing a code for collecting, perhaps harking back to the nineteenth century initiative taken by the RES but never formalised (Collins et al. 1988, and above). Considerable trouble and effort was taken to consult interested parties, with one of which (the Rothamsted Insect Survey) it was agreed to differ over certain aspects. The Committee's Secretary and Mr Alan Kennard, in particular, devoted much time to getting the code into an acceptable format and it was not until a special meeting of the Committee on 2 June 1971 that the final text (together with a 'list of rarities') was agreed. This was followed by a period during which the code was approved by the national entomological societies; for example the BENHS gave it its blessing and recommended its members to abide by the code (JCCBI 1972a). It was then published more widely, in *Entomologist's monthly Magazine* (with an enthusiastic welcome) (JCCBI 1972b), *Entomologist's Record and Journal of Variation* (JCCBI 1972c), *Entomologist's Gazette* (JCCBI 1972d) and *The Entomologist* (JCCBI 1972e).

To reinforce the code, lists of rare and endangered macrolepidoptera (JCCBI 1973a), Odonata and Orthoptera (JCCBI 1973b) and a general list of rare and endangered insect species (JCCBI 1973c) were produced. These are now only of limited and historical value, having been almost immediately overtaken by the Wild Creatures and Wild Plants Act (1975) and then by subsequent legislation and other accounts (e.g. Shirt 1987), and by the inevitable changes in status brought about by a multitude of different factors.

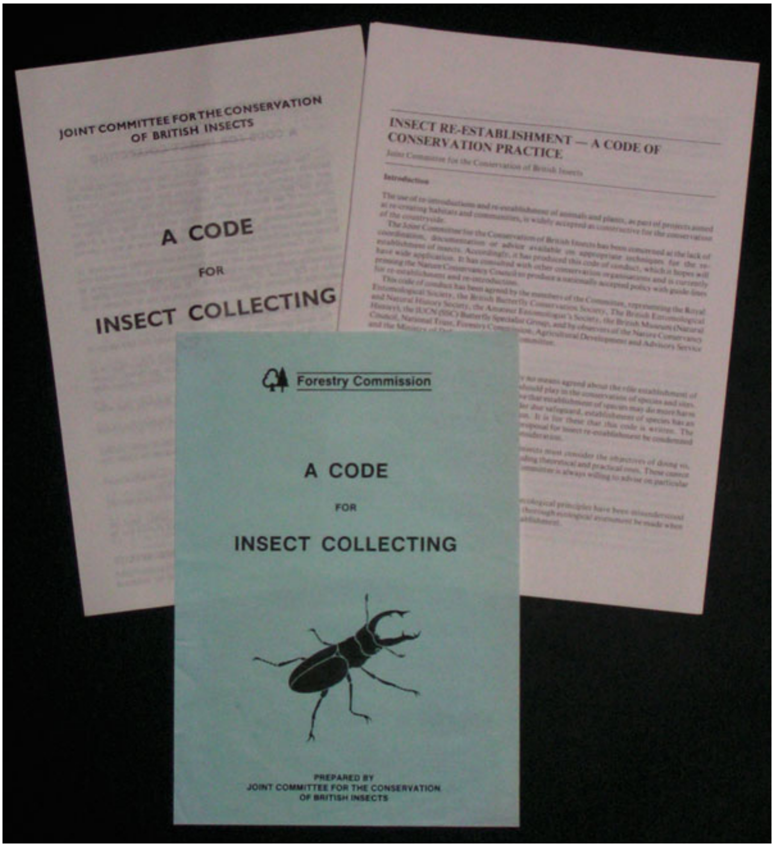

Fig. 2.1 Examples of JCCBI outputs. Clockwise from above left: original code for collecting (1972), code for re-establishment (1986), re-issued code for collecting (1987).

The code is undoubtedly one of the lasting achievements of the Committee. In addition to its publication in entomological journals, the original version was produced as a separate leaflet (Fig. 2.1), in a print run of 100,000 copies, and distributed widely to entomologists and others. In 1973, copies were sent to all Naturalists' Trusts (now Wildlife Trusts) and natural history societies. Since that time, it has been reproduced in many books and pamphlets, and the leaflet was reprinted by the Forestry Commission (with minor amendments) as JCCBI (1987) (Fig. 2.1). The Committee subsequently devoted considerable time to revising and updating the code, although the core principles remain unchanged, resulting in its reissuing as Invertebrate Link (JCCBI) (2002). A feature which adds particular value to the code is that it has been developed and endorsed by such a wide range of bodies concerned with the study and conservation of invertebrates. It represents the widespread desire, across the entomological community, to promote a rational and responsible approach to collecting, avoiding any need for draconian restrictions that could impede the fundamental studies that are vital to underpin conservation efforts.

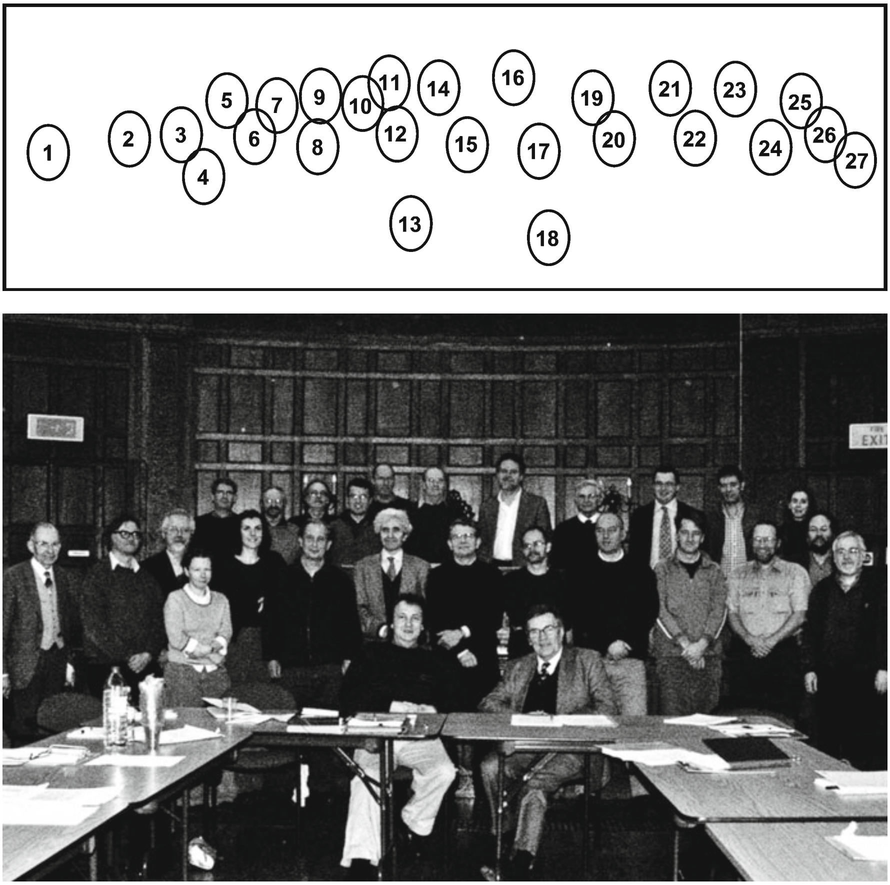

Fig. 2.2 Attendees at the 81st Meeting of Invertebrate Link (JCCBI), held at the Royal Entomological Society, 41 Queen's Gate, London, on 2nd March 2006: (1) Raymond Uffen – Representative, British Entomological & Natural History Society and Bees, Wasps & Ants Recording Society. (2) Andrew Halstead – Representative, Royal Horticultural Society. (3) Peter Barnard – Representative, Natural History Museum. (4) Alice Hiley – Representative, Environment Agency. (5) Andy Foster – Representative, National Trust. (6) Caroline Daguet – Representative, British Dragonfly Society. (7) David Smallshire – Representative, Department for Environment, Food & Rural Affairs (Rural Development Service). (8) Alan Stubbs – Representative, Buglife. (9) Adrian Fowles – Representative, Countryside Council for Wales. (10) Mark Telfer – Representative, Royal Society for the Protection of Birds. (11) Keith Alexander – Representative, Ancient Tree Forum. (12) David Lonsdale – Representative, Amateur Entomologists' Society. (13) Oliver Cheesman – Chairman, InvLink. (14) John Phillips – Representative, British Entomological & Natural History Society. (15) Martin Willing – Representative, Conchological Society of Great Britain & Ireland. (16) Alan Stewart – Representative, Royal Entomological Society. (17) Ian Middlebrook – Representative, Action for Invertebrates. (18) Michael Morris – Honorary President, InvLink. (19) Norman Hall – President Elect, British Entomological & Natural History Society [guest]. (20) John Dobson – Representative, Dipterists' Forum. (21) Matt Shardlow – Representative, Buglife. (22) Mark Parsons – Representative, Butterfly Conservation. (23) Paul Lee – Representative, British Myriapod & Isopod Group. (24) Keith Bland – Representative, National Museums of Scotland. (25) Louise Allcock – Representative, Linnean Society. (26) Roger Key – Representative, English Nature. (27) Dafydd Lewis – Representative, Amateur Entomologists' Society

2.6 Legislation and Collecting

The nineteenth century origins of the Committee in entomologists' own concerns about over-collecting, the importance of collecting for the study of many invertebrate taxa, and the value of a voluntary Code of Conduct for collecting which is broadly supported across the entomological community, are all noted above. The promotion of species conservation through the most effective means, such as protection and appropriate management of habitats (e.g. see Fry and Lonsdale 1991; Kirby 2001), rather than measures that could do more to inhibit the study of invertebrates than enhance their conservation, such as restrictions on collecting where there is no evidence that this is a threat to natural populations, has been a recurrent theme in discussions of the Committee, particularly in relation to legislation.

JCCBI held a special meeting at 19 Belgrave Square (then the Headquarters of the NCC) in September 1979 to discuss comprehensive legislation and to ensure that the interests of field entomologists were considered along with the conservation of species and their habitats. The quinquennial reviews of species scheduled for protection under the Wildlife and Countryside Act (1981) are perennial items for consideration by the Committee, which has also contributed to reviews of other aspects of the Act, most recently applying the principle that it would seek to 'Secure improved conservation of invertebrate populations with minimisation of hindrances to the legitimate study of invertebrates'. Other elements of legislation and policy discussed by the Committee in recent years include implications of the integration of the EU Habitats Directive into UK law (e.g. see Phillips 2008), and museum policies for the acceptance of donated specimens and collections (e.g. see Anon 2007).

Attempts to produce a general statement on the role of legislation in species protection have occupied the Committee, quite literally, for years. After protracted discussions, a statement was finally agreed in 1995, but this was never published. When it was resurrected in 2002, years of discussion again ensued over the purpose and wording of the document. The statement was finally agreed in 2007, and published as Invertebrate Link (JCCBI) (2008).

2.7 Survey Work

Survey work was deemed to be an important activity to which JCCBI could contribute in its earlier days, but lack of core resources inhibited this. Grant–giving bodies filled some of the lacunae: Shell had earlier supported entomological surveys led at various times by W. D. Hincks, E. C. Pelham-Clinton, and W. O. Steel (hence the 'Steel Band' as a popular name), and the Committee profited from this source too, as well as from project funding from WWF. Surveys of the status of the Adonis Blue butterfly *(Lysandra bellargus*) in Dorset and Chequered Skipper butterfly (*Carterocephalus palaemon*) in England were made by Robin Buxton and Lynne Farrell respectively, and reports produced. These were the forerunners of more extensive surveys undertaken by Butterfly Conservation and under the highly successful Butterfly Monitoring Scheme devised by Dr E. Pollard (Pollard and Yates 1993).

The Committee ensured that Lepidoptera continued to occupy an important place it its concerns when Dr Jeremy Thomas was co-opted as Surveys Officer in 1978, and succeeded in this role by Martin Warren, who was in turn succeeded by Paul Waring. Reports from particular surveys (including joint field meetings with BENHS) were made at JCCBI meetings up until the mid-late 1990s; the post of Surveys Officer was eventually abandoned in 2000. However, as an encouragement to best practice in this area, the Committee developed a set of site survey guidelines, which were published as Brooks (1993).

2.8 Other Publications and Reports

Although it did not publish the account, JCCBI was heavily involved in discussion on, and support for, the conservation of dead wood fauna and flora (Stubbs 1972). This early publication was, in many ways, a starting point for the important and well documented issue of the conservation of the 'saproxylic fauna' and extension to the importance of Urwaldtiere, ancient forests and pasture woodlands (e.g. Harding and Rose 1986; Harding and Wall 2000, and references therein).

Over a decade after publication of the 'Code for Insect Collecting' the Committee published a code of conservation practice for the re-establishment of populations of locally extinct species (JCCBI 1986) (Fig. 2.1). This was based on ecological and other considerations that were set out by Morris and Thomas (1989) and followed the well-publicised extinction of the Large Blue butterfly (*Maculinea arion*) as a British species in 1979. While the spectacular success in the re-establishment of this species achieved by Professor Thomas and his co-workers (e.g. Thomas et al. 2009) owes nothing to JCCBI except Committee's whole-hearted moral support, it demonstrates the need for a well planned and soundly based approach, as emphasised by the code.

In fact, however, the code for re-establishment did not achieve the initial success of the code for collecting. In part, this was due to some reservations over its provisions expressed by certain entomologists, and partly because encouragement to record and archive attempts at re-establishment proved ineffective. The code has now been exhaustively reviewed, revised, and updated (Invertebrate Link (JCCBI) 2010) and addresses the issue of translocation more broadly, but the lack of a comprehensive and thorough system for recording re-establishment attempts remains unresolved.

Another early code that the Committee produced was one of good practice for entomological dealers. Robert Goodden was instrumental in drafting it, being a conservationist as well as a proprietor of one of the first 'butterfly farms' and a supplier of equipment, books and specimens. The current authors are not aware that the code reached a wide audience or that it is effective today. Also highlighting butterflies was Dr Mark Collins's report on 'butterfly houses' that were undergoing a period of rapid proliferation, and the advent of 'Butterfly Year' in 1982, for which the Committee produced a coloured information leaflet.

The lists of insect species at risk (JCCBI 1973a, 1973b, 1973c) paved the way for the Red Data Book on insects (Shirt 1987). The Committee played a prominent role in the book's prolonged period of preparation and assessment, with its Secretary chairing both the selection and publication committees, though these were largely *ad hoc*. Perhaps because of the long drawn out processes, of selection in particular, 'amendments' and 'revisions' to the Red Data Book (e.g. Hyman and Parsons 1992) have been made without re-convening the committee or seeking systematically the wider advice of experts, both within and outside JCCBI, sometimes with questionable results.

2.9 Conferences, UK BAP and the Birth of Buglife

In November 1984, the AES submitted to JCCBI a discussion paper (known colloquially as the 'pink paper'), which addressed various aspects of the Committee's operations and limitations. Amongst other things, it proposed the establishment of an Executive subcommittee to advance matters between the twice-yearly 'main' meetings of the full Committee. This recommendation was accepted at the following JCCBI meeting in March 1985, and the 'Exec' was duly established, initially with Paul Whalley chairing. The 'pink paper' also proposed a debate on the possible need for a new structure or organisation to promote insect conservation in a more proactive fashion than JCCBI (as a forum for bodies with differing areas of interest in this broad field) could achieve, particularly given its lack of financial resources.

Amongst ideas for the reinvigoration of the Committee proposed in 1993 was a conference to explore what was required to advance invertebrate conservation in Britain, and JCCBI's possible role. In the same year, a small group of influential NGOs came together as *Biodiversity Challenge*, and guided the UK Government's hand in its development of a UK Biodiversity Action Plan (BAP), a key response to the Convention on Biological Diversity. The invertebrate perspective was provided by Alan Stubbs, representing Butterfly Conservation on *Biodiversity Challenge*. Whilst JCCBI was not directly involved in the work of this group, it received regular progress reports and views were fed back informally. Despite some dissatisfaction over the process, and the suitability of the selection criteria, invertebrates were better represented amongst the first set of UK BAP priority species than many had feared. In recognition of the UK BAP as a key driver over the coming years, it was agreed that JCCBI would hold a conference in 1996, focusing on emerging opportunities for invertebrate conservation, and the need to encourage a sense of 'unity of purpose' in pursuing these.

The first JCCBI Conference was held in Peterborough on 24 February 1996 (Brooks 1997). One of the specific issues raised was (again) the potential need for a new national organisation, devoted to invertebrate conservation, which could be more proactive than JCCBI. Alan Stubbs, in particular, subsequently championed this idea, and JCCBI acted as a sounding board and (to some extent, at least) co-ordinating body. Later in 1996, an Invertebrate Conservation Trust Feasibility Committee was formed, almost exclusively from around the JCCBI table, but acting independently of JCCBI itself. This group produced a 'Statement of need for a new organisation', which was presented for discussion at a second JCCBI Conference, held on 27 September 1997 (Brooks and Nellist 1998). Whilst the details remained a matter of great concern to some, there was growing support for a new organisation, and delegates at the second Conference voted almost unanimously in favour of its establishment.

Again through JCCBI, it was agreed (in 1998) to produce a 'Green Paper', providing more detail on the nature and role of a potential Invertebrate Conservation Trust. This document (Willing 2000) was redrafted a number of times, to take account of rapidly changing circumstances, and was finally circulated in time for a third Conference on 31 March 2001 (Cheesman 2004). By this stage, steps towards establishment of the new organisation were so advanced that the conference was used to launch it to the wider invertebrate conservation community; an official, public launch would come later. As well as unveiling and encouraging discussion on the new Invertebrate Conservation Trust, the third conference also provided an opportunity to examine progress made in other areas. This included the establishment of two new posts to help progress activities under the UK BAP. One was the *Action for Invertebrates* post, resourced by *Biodiversity Challenge* and English Nature; the other an Invertebrate Biodiversity Co-ordinator post, supported by English Nature and the Natural History Museum (NHM) and based at the Museum, alongside a parallel post for lower plants. Whilst InvLink lacked the funds or physical resources to support these posts, it was involved in the development and management of both.

InvLink's meeting in early 2002 was timed to allow for discussions of Trustee nominations, ahead of the first Annual General Meeting (AGM) of the Invertebrate Conservation Trust, which had now adopted the name 'Buglife' and appointed its first paid staff (Chap. 4, this volume). Alternative arrangements for overseeing the organisation's governance were soon developed, quite rightly, allowing Buglife to operate independently of InvLink. A fourth Conference was to have been held in April 2003, to coincide with the second Buglife AGM, allowing the opportunity (amongst other things) to clarify to a wider audience the respective roles of the two bodies, but it had to be postponed.

With Buglife established and operating independently, InvLink was able to turn its attention to other themes for its conferences. The fourth of these took place on 3 April 2004, examining the issue of Favourable Conservation Status, a concept which it was felt had been poorly defined, particularly in relation to invertebrates. During and after the work to establish Buglife, InvLink remained involved also in aspects of the UK BAP. It issued, but never formally published, guidance on important habitats for invertebrates (Lott and Stubbs 1999), and provided a co-ordinating mechanism, with the Joint Nature Conservation Committee (JNCC), for input and assessment of invertebrate information for the 2005 review of UK BAP Priority Species (Invertebrate Link (JCCBI) 2004). This proved to be a protracted process, although it resulted in better representation of invertebrates amongst the new list of

Fig. 2.3 Animated panel discussion at the fifth Invertebrate Link (JCCBI) Conference, held at the Natural History Museum, London, on 9th November 2006. Left to right: Steve Tilling (Field Studies Council), Lynn Hughes (Oxford Brookes University), Roger Key (Natural England), Martin Sanford (Suffolk Biological Record Centre), Nick Baker (TV naturalist and author), Mark Boyd (Royal Society for the Protection of Birds) (Photograph: Martin Willing)

Priority Species once this was finally agreed. Currently, there are significant concerns, however, over how work on these species is to be resourced.

Amid concerns over the decline in taxonomy (professional and amateur) and the natural history tradition in Britain, the fifth InvLink Conference (Masters et al. 2007) was held on 9 November 2006 (Fig. 2.3). The issues addressed are explored in more detail in Cheesman and Key (2007). Whilst a number of useful initiatives have since been undertaken, the Committee remains very concerned over the state and future of taxonomy, reduced opportunities for (particularly young) people to connect with nature, and implications for the study and conservation of invertebrates.

2.10 The Future

Since the formation of JCCBI in 1968, the Committee has periodically been criticised (not least from within) as being little more than a 'talking shop'. The various outputs of the Committee demonstrate that it is more than this, although its activities are undoubtedly constrained by its almost exclusive reliance on voluntary effort. The criticism also fails to acknowledge that a core function of the Committee has always been, and remains, to provide a forum for dialogue across an increasingly broad constituency of organisations. This provides not only for the formal development of collective views, but generates the many intangible benefits of informal networking. Achieving consensus has never been easy among the disparate groups concerned with the study and conservation of invertebrates, and the increasing diversity of organisations represented on InvLink has probably introduced an ever wider set of views, priorities and interests – there is always the potential for internal disputes, whether based on differences of opinion or simply clashes of personalities.

Feedback from representatives of member organisations tends to suggest that, whilst InvLink is far from perfect, 'if we didn't have it, we'd have to invent it'. Even though changes in communication technology over the last 40 years means that almost anyone can be contacted rapidly, and views shared widely, by an exchange of e-mails, the value placed on InvLink meetings seems to support the maxim that 'you can't see eye-to-eye unless you meet face-to-face'. This, and the need for a forum in which to explore and develop collective views, seems unlikely to change. On the one hand, this need reflects the ever greater conservation challenges that seem likely to be faced in coming years. However, more positively, it reflects also the extent to which the relevance of invertebrate conservation has become increasingly recognised, amongst organisations directly concerned with biodiversity issues and more broadly.

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Chapter 3
A History of Invertebrate Conservation in the British Statutory Conservation Agencies

Ian F.G. McLean and Roger S. Key

3.1 General Background

The history of nature conservation in Britain before the establishment of the Nature Conservancy (NC) in 1949 is summarised by Sheail (1976), who describes the history of wildlife protection legislation, the establishment of voluntary bodies and the selection, acquisition and management of nature reserves. Despite some recognition of their ecological importance and huge diversity, because of their forbiddingly large number of species, invertebrates lagged behind vertebrates and plants in terms of conservation attention during this era. Within the statutory conservation sector, invertebrate conservation began on the fringes of mainstream ecology and conservation thinking in the 1950s, became established as a worthwhile endeavour in its own right in the 1960s and 1970s in Britain, consolidated and grew in stature through the next two decades and then diversified and developed more strongly within the voluntary sector in Britain.

Some noted entomologists first became involved with nature conservation around the end of the Victorian period, perhaps particularly in response to the losses of fenland insects due to drainage of the East Anglian Fens. These included the hugely symbolic loss of the indigenous subspecies of the Large Copper butterfly (*Lycaena dispar dispar*) in the middle decades of the Nineteenth Century, although doubtless many other extinctions of wetland insects went unnoticed. One of the largest remaining areas that remained undrained was Wicken Fen, which was a well-known haunt for moth hunters and other entomologists throughout the Nineteenth Century (Charles Darwin collected beetles there in the 1820s). The National Trust bought its first plot on Wicken Fen on 1 May 1899, while the entomologist the Hon. N.C. Rothschild

I.F.G. McLean (✉)
109 Miller Way, Brampton, Huntingdon, Cambridgeshire PE28 4TZ, UK
e-mail: ianmclean@waitrose.com

R.S. Key
The Old Black Bull, Carthorpe, Bedale, North Yorkshire DL8 2LD, UK

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donated further areas of fen in 1901 and the dipterist G.H. Verrall bought up many tiny plots and on his death in 1911 he bequeathed 239 acres to the Trust (Colston and Friday 1999). Rothschild went on to buy Woodwalton Fen in 1910 and in 1912 to found the Society for the Promotion of Nature Reserves (SPNR), later to become The Wildlife Trusts. He made many contributions to establishing the standing of nature conservation as a worthwhile activity in Britain, as well as initiating practical measures to conserve species and their habitats until his death in 1923 at the age of 46 (Rothschild and Marren 1997).

Both within the voluntary sector and in the NC the establishment of invertebrate conservation depended upon the efforts of a small number of talented and determined individuals who refused to give up despite the enormous and daunting task that they faced with little support and very limited resources. Their story deserves to be better known, not least because in many other countries the same obstacles they faced need to be overcome if the most and abundant and diverse groups of organisms on earth are to be conserved successfully in future. This account attempts to highlight some of the most significant stages in the progress of invertebrate conservation in Britain within the statutory conservation agencies and also to draw attention to the key people and their achievements. The references cited comprise only a small proportion of the books and papers that have been published, although they contain further references to much of the important literature in this field.

There are huge challenges in conserving invertebrates, not least because of their limited public appeal, small size, identification difficulties, immense species richness and diversity of lifestyles coupled with their vulnerability to local extinction when their special requirements disappear even for just a year. Nevertheless, we now know enough about the ecological principles underlying invertebrate conservation biology, as well as having detailed information about the specific needs of a range of threatened species, to enable many of the threats to invertebrates in Britain to be addressed. That this is the case is in no small measure due to the pioneers in the 1950s and 1960s in the NC who laid the foundations upon which their successors have consolidated over the subsequent 40 years.

The approach adopted here is broadly chronological, with approximately decadal sections giving a structure within which broad themes can be identified and key people and projects can be placed within their historic context. Some accounts of the contributions made by individual people are given as a short synopsis in one section to simplify the structure of the chapter.

3.2 Early Years: The Inception of the Nature Conservancy Until 1960

In 1915 the SPNR produced a list of 284 potential nature reserves in Britain and Ireland, which was presented to the Board of Agriculture in the hope that the Government might offer the sites some protection (Rothschild and Marren 1997). However, the First World War, together with indifference by the Board of Agriculture, stymied this proposal. The end of the Second World War saw a re-awakening of interest in the environment. The need for organized nature conservation and a national wildlife service was expressed by influential academics such as Professor Sir Arthur Tansley (Tansley 1945). He pointed out the beauty and interest of invertebrates and the importance, when considering wildlife, of including all kinds of animals, not just those that are large and well known.

Some of the key players who worked in the early years of the NC, had strong interests in natural history, including invertebrates. It was an era when the number of professional ecologists and entomologists was small and many scientists worked in an amateur capacity in their spare time while pursuing a career in another sphere. Their capacity for hard work in conducting studies involving species-rich groups of invertebrates seems to have pre-adapted them for the challenge of establishing a new organisation in a society where there were many competing demands for public funds and little general appreciation for the needs of wildlife in a countryside recovering from intensive agricultural exploitation of the Second World War. The 1950s saw a rapid expansion in the number of National Nature Reserves (NNRs) to a total of 72, with a staff total approaching 200 (Sheail 1998), but there were already signs that loss and damage of sites to development and intensive agricultural and forestry practices were causing wildlife declines, although at this stage there was an absence of good evidence that invertebrates were being adversely affected, other than for some species in well-studied groups such as butterflies and dragonflies. The network of Sites of Special Scientific Interest (SSSIs), the major statutory designation for conserving both biological and geological sites, was initially set up on the basis of the best-known sites for particular habitats and species, which in some cases included insects (mainly in the more popular and well-studied groups such as Lepidoptera and Odonata).

Captain Cyril Diver was the first Director-General of the NC, being appointed in 1948 and continuing in that role until he retired in 1953 (Merrett and Ford 1971). He was responsible for establishing measures to safeguard sites, principally by notifying SSSIs, for recruiting staff (the total had reached 66 by the time he retired) and for developing relationships with other Government bodies, landowners and relevant scientific organisations. Prior to his appointment as Director-General he was Secretary to the committee, chaired by Sir Julian Huxley, that drafted Command Paper 7122 resulting in the establishment of the NC and a fresh and more active approach to conserving Britain's environmental heritage. For many years he had coupled his career as Clerk of Committees at the House of Commons with ecological research in the long vacations that his post allowed! He investigated the distribution of snails in relation to their inherited shell patterns, as well as conducting detailed plant and animal surveys at Studland, Dorset in heathland and coastal habitats, ably assisted by his wife and teams of volunteers. He also had a great interest in the ecology of ants, including factors influencing their territories, and hoverflies; his interests were driven by a great intellectual curiosity regarding evolutionary ecology coupled with a naturalist's fascination with the daily affairs of many groups of organisms. His scientific achievements were widely recognised (for example, he was elected President of the British Ecological Society and also President of the

British Conchological Society) and his great energy and industry resulted in the publication of 37 papers as well as numerous extensive unpublished accounts.

Sir Arthur Duncan succeeded Sir Arthur Tansley as Chairman of the NC in 1953 and retired in 1961. He persuaded Max Nicholson to join the Conservancy as Director-General and he oversaw the establishment of many NNRs, as well as striving to strengthen the science base of the organisation by developing work with the British Trust for Ornithology (Watson 1985). He was a gifted naturalist with strong interests in field entomology, including bumblebees and other aculeates, moths and various families of flies. His strong and confident leadership of the fledgling organisation did much to get things done and his background as a farmer, coupled with his natural history knowledge, ensured that practical conservation was understood in Council discussions and invertebrate conservation was regarded sympathetically at the top level.

Norman Moore had successively a wide range of responsibilities, beginning in 1953 as NC Regional Officer for South-west England, where he researched the history of Dorset heaths in a classic paper showing the losses that had taken place (Moore 1962), then leading research into the effects of organochlorine insecticides at Monks Wood Experimental Station (within the NC) in the 1960s, until he finally became the Chief Advisory Officer for NCC in 1979 until his retirement in 1983. His life-long passion for dragonflies (including significant involvement with their conservation internationally) includes research into their adult population density (Moore 1953), the collaboration with Philip Corbet and Cynthia Longfield in publishing the *New Naturalist* volume on dragonflies (Corbet et al. 1960), and preparing guidelines for monitoring dragonflies (Moore and Corbet 1990). Coupled with his wide-ranging interests in science and policy (Moore 1987) and practical conservation (Moore 2002) he has made a huge contribution towards the acceptance of invertebrate conservation as a worthwhile subject to be taken seriously in its own right. There is room here only to mention a few of his achievements involving invertebrates, but his intellectual influence within the statutory conservation agencies has been much wider, including when setting out the first rationale and guidelines for selecting SSSIs when he chaired an internal NCC working group from 1975 onwards. He has maintained close relationships with many naturalists and wildlife organisations, while at the same time he has worked closely with farmers and was instrumental in the establishment of the Farming and Wildlife Advisory Group (FWAG), which since 1969 has made many improvements to management of farmland for the benefit of invertebrates and other wildlife.

Moore appreciated the importance of taking the long view when examining ecological changes and their significance for nature conservation. He has conducted many detailed and long term studies, including of the wildlife in the vicinity his home in Cambridgeshire. In Moore (1990) his account of the changes that took place at Bar Hill from 1966 to 1988, following the development of the new town there, includes his observations of butterflies and dragonflies. Their changing fortunes are set in the context of the major losses of, and alterations to, the original arable farmland and its associated habitats. His investigation of dragonfly communities on experimental ponds at Woodwalton Fen NNR (Moore 1991) is one of the few experimental studies involving ecological manipulation on a NNR; such inventive experimental studies unfortunately have become unfashionable and rare on statutory reserves in Britain.

A contemporary of Norman Moore, Eric Duffey, was appointed as NC Regional Officer for East Anglia in 1953 and maintained a keen interest in the ecology and conservation of spiders as well as in broader issues of conservation management and site protection. His location in East Anglia enabled him to develop a deep interest in fenland habitats, their flora, fauna and conservation and he made the major discovery of the emblematic wetland Fen Raft spider *Dolomedes plantarius* in Suffolk (Duffey 1958), a species now known to be threatened throughout much of its European range. He became interested in other fenland species and while based at Monks Wood as Head of the Conservation Research Section led the work on conserving the introduced population of the Large Copper butterfly at Woodwalton Fen NNR (his conclusions were published in Duffey 1977). As well as his continued interest in fenland spiders, most recently exemplified by his summary of past major surveys in Duffey and Feest 2009, he did much work on the spiders of calcareous grassland and he also became concerned with international conservation issues and major sites (such as Ascension Island, see Duffey 1964). An early review of the invertebrates of the Chalk was published (Duffey and Morris 1966), leading to further research including the investigations of the effects of management upon invertebrates (and plants by Terry Wells) and also to a major symposium on *The scientific management of animal and plant communities for conservation* (Duffey and Watt 1971). This was a time when at last with the strengthening of the NC's research capacity, detailed ecological investigations were being deployed to assess the effects of different management regimes on invertebrates and other wildlife in Britain's intensively managed landscapes and nature reserves. The special issue of Biological Conservation in 2000 as a Festschrift for Eric Duffey (Davis 2000) includes work inspired by him and more references to his wide-ranging conservation publications.

3.3 The 1960s: Pesticides and the Growth of Conservation Research

A detailed account of the history of pesticides in relation to conservation is given by Sheail (1985), so this ground is not covered again here. There had been concerns expressed at the possible impacts of persistent pesticides such as the organochlorine DDT on wildlife and human health since the early 1950s in Britain and elsewhere, increased by observations of deaths of birds and foxes in the later years of the decade. The NC received approval in 1960 to establish a research station at Monks Wood near Huntingdon, in part to investigate the effects of toxic chemicals upon wildlife. Increasing alarm was expressed in newspapers in Britain at what was happening to wildlife, reinforced in 1962, when *Silent Spring* by Rachel Carson (Carson 1962) was published in the United States, hence the new research station was very much in the public eye from its inception. Nevertheless, it was only much later that long term data on the abundance of invertebrates in the wider countryside became available (for example, see Aebischer 1991), too late to influence the 1960s pesticide debate although of great significance in revealing the extent and nature of changes in intensively managed cereal crops.

Another impetus behind the establishment of Monks Wood Experimental Station was the need, very clearly expressed by Norman Moore and Eric Duffey, to understand better the habitat requirements of different groups of wildlife. This resulted from observations of losses of rare species from NNRs during the 1950s, including invertebrates, and the desire to discover how these losses might be prevented by managing nature reserves better.

The Biological Records Centre (BRC) was established at Monks Wood in 1964 under the leadership of Franklyn Perring (Harding and Sheail 1992), with lepidopterist John Heath appointed as zoologist in 1967 responsible for developing recording of insects and other invertebrates. The first provisional insect distribution atlas was published in 1970 (Heath 1970), dealing with British butterflies, which led to the publication of a comprehensive atlas in 1984 (Heath et al. 1984). BRC rapidly became the focal point for collecting together the huge number of species observations for plants and animals (excluding birds, dealt with by the British Trust for Ornithology) made by competent naturalists all over Britain. The number and extent of these observations has increased year on year since then, fostered by a suite of national recording schemes led by specialists in their respective taxonomic groups. The oft-cited claim that Britain has the best-known flora and fauna in the world can now be supported by the statistics for the number of species records published in national atlases and more recently made available via the National Biodiversity Network (NBN) Gateway (with over 64 million species records accessible as of July 2011: http://data.nbn.org.uk/).

A seminal event in the history of invertebrate conservation within the statutory conservation agencies was the first Symposium at Monks Wood Experimental Station, held on 23–25 March 1965. The event was attended by 31 staff from the Conservancy (and five others from outside), the list reading like a roll call of distinguished entomologists of the time who were concerned to see invertebrate conservation given greater emphasis at a time of growth and development within the NC. It was organised by the Conservation Research Section and the Proceedings were edited by Eric Duffey and Michael Morris (1965), the included papers and summary of discussions giving a fascinating glimpse of both long-standing and emerging issues and the concerns and viewpoints of leading entomologists of that era.

The latter part of the decade saw more research and publications on invertebrate conservation emerge from the teams at Monks Wood, including an assessment of the butterflies represented on NNRs (Morris 1967a), then a series of papers by Michael Morris on the invertebrate fauna of grazed and ungrazed chalk grassland (Morris 1967b, 1968, 1969a, b, 1971) based upon research conducted at Barton Hills Bedfordshire, which were later synthesised with other studies to give an overview of grassland ecology and its management for wildlife (Duffey et al. 1974). Later on he extended this work by examining the effects of cutting upon selected groups of grassland invertebrates (Morris and Lakhani 1979; Morris 1979, 1981a, b), research which continues to be relevant to those concerned with the effects of alternative management regimes on the grassland fauna.

3.4 The 1970s: Accelerating Habitat Losses and Species Declines and Their Consequences for Invertebrates

Throughout the 1970s in Britain the pressures of development and agricultural intensification continued to take their toll on the most important sites (SSSIs) and on threatened species. There was increasing concern at the apparent declines in many insects, notably butterflies, but a lack of published evidence that could lead to changes in policy and attitudes to make a difference on the ground. It was not until the passing of the Wildlife and Countryside Act in 1981 and the accumulation of evidence from the 1980s onwards for the decline of many invertebrates, that these losses were slowed but not halted.

The Nature Conservancy Council (NCC) was vested on 1 November 1973 becoming the Government agency responsible for delivering nature conservation, with the former research branch of the NC becoming the Institute of Terrestrial Ecology (ITE). Sheail (1998) includes a detailed historical account of the events leading up to the creation of the new organisations and the implementation of the Rothschild Principle for Government purchase of scientific research.

In this account of invertebrate conservation in the statutory conservation agencies, the main emphasis after the split of the NC into NCC and ITE is upon the work of NCC and its successor agencies, but conservation work carried out by ITE (and its successor the Centre for Ecology and Hydrology, CEH) often under contract to the agencies, is also mentioned selectively to attempt to give a reasonably full picture of invertebrate conservation funded by government.

The publication of the detailed account of Monks Wood NNR (Steele and Welch 1973) 10 years after the establishment of the research station was an opportunity to demonstrate how detailed research could improve knowledge of a nature reserve. The book included checklists for major invertebrate groups and some comments on their significance, while the ‘Conservation and Management’ chapter summarised how the interest of the reserve was being sustained, including by active management of rides and coppice plots. This was before the importance of early successional stages in woodlands and other habitats for many invertebrates had been demonstrated by Jeremy Thomas and others, but there was an understanding that continued management was needed to maintain the diversity of conditions in the wood together with their characteristic flora and fauna. Although it was intended that further similar volumes on NNRs would be published, this was not achieved by NCC or its successors, although similar site accounts have been published subsequently elsewhere for areas such as the Norfolk Broads (George 1992) and Moccas Park (Harding and Wall 2000). These books are similar in their scope and content to the Monks Wood volume and include extensive accounts of their invertebrate faunas. Massey and Welch (1994) reviewed the experience gained from managing the wood for nature conservation for 40 years (1953–1993). Another significant publication from the time of the Monks Wood book was the *New Naturalist* volume on Hedges (Pollard et al. 1974), which demonstrated the value of these long-established landscape features in Britain for many groups of wildlife including invertebrates.

The establishment in NCC of a Chief Scientist Team (CST) under Derek Ratcliffe in 1974 was aimed to set the scientific standards within the new NCC, oversee contracts with ITE, universities and others as well as to develop the different conservation disciplines as staff and other resources allowed. Alan Stubbs was appointed to lead invertebrate conservation work, as well as recreation and mineral exploitation (with urban conservation added to his portfolio in 1977). Initially the CST was largely based at an office in Huntingdon but with some specialists (including Alan Stubbs) based at the NCC GB headquarters in Belgrave Square, London. He had previously been Deputy Head of the Geology and Physiography Section at Newbury, where his wide-ranging fieldwork duties had also enabled him to become acquainted with many important invertebrate sites in Britain. Derek Ratcliffe as Chief Scientist had a very simple approach with his team members, on day one Alan was the entomologist, Derek was not – "so get on with it!"

The key roles of commissioning research, acting as a specialist advisor to NCC regional staff, and developing policy and a strategy for invertebrate conservation within NCC were in common across the different specialisms in CST. The research programme was subject to rigorous reviews of its rationale, purpose and cost effectiveness. The advisory role was largely reactive to issues arising from operational staff. The policy and strategy aspects were more concerned with the longer term goal of developing the effectiveness of invertebrate conservation itself. This was all set against a background of damage and destruction to many SSSIs and to important invertebrate sites with no protection at that time. NCC staff needed support and guidance when dealing with invertebrate conservation issues and had the advantage of addressing site threats with the available statutory instruments (although these had severe limitations in many cases). At this time the Non-Governmental Organisations (NGOs) in the conservation sector were much weaker in terms of staff and financial resources than was the case 20–30 years later. Hence a pragmatic decision was taken to concentrate on developing the skills of NCC staff rather than working directly with the NGOs: if NCC regional staff were better orientated, that would also improve their advice to conservation NGOs.

The development and launch of a national Butterfly Monitoring Scheme led by Ernie Pollard (ITE Monks Wood under an NCC contract) was one of the highlights of the decade. The impetus for the scheme came from increasing concerns at the apparent decline of many butterflies and the need to identify the causal factors, the possibilities including habitat loss and change, changing farming practices and increasing use of pesticides. After pilot studies at Monks Wood NNR, the Butterfly Monitoring Scheme was established nationally in the long hot summer of 1976 and was extended subsequently throughout England, Scotland and Wales with transects established mainly on nature reserves where wardens and volunteers carried out weekly walks from the beginning of April until the end of September. Pollard recognised from the beginning the importance of providing regular feedback to recorders to sustain their interest and enthusiasm, as well as publishing the results in different forms aimed at a range of audiences including butterfly enthusiasts and amateur naturalists, conservation managers and practitioners and also ecologists and population ecologists. The partnership between the statutory conservation agencies (whose staff counted many of the transects on NNRs) and ITE (who organised the scheme, conducted analyses and published the results) enabled the scheme to survive periods of financial stringency in both the conservation agencies and in ITE, as well as overcoming the strains and rifts engendered by the customer-contractor relationship established at the inception of NCC and ITE.

The Butterfly Monitoring Scheme method was quickly published in a peer-reviewed journal (Pollard 1977), followed by a progress report to entomologists (Pollard 1979) and then a summary of the first decade's results for conservationists (Pollard et al. 1986). Ecologists and population ecologists were addressed in papers such as Pollard (1984, 1988), which demonstrated the importance of weather factors in changing the number of adult butterflies from year to year, as well as the significance of habitat management in setting the potential carrying capacity of a site or area. The book (Pollard and Yates 1993) reviewing the key findings for the scheme was of great interest to a wide range of amateur and professional butterfly specialists, giving an extensive overview of what had been discovered about populations of different species, their range changes, the effects of the structure of habitats sampled and more detailed accounts of what had happened on individual nature reserves.

Later work (by Butterfly Conservation in the 1990s in conjunction with CEH) has combined analyses of monitoring and distribution mapping studies to show how different factors (including climate change) are affecting the abundance and distribution of butterflies in Britain. Butterflies are now recognised as one of the most sensitive indicators of the consequences of climate change, with important implications for developing effective conservation strategies at a landscape scale for butterflies and many other invertebrates with similar responses to weather and to habitat structure.

The UK Butterfly Monitoring Scheme has achieved international recognition for its technical success as a method for measuring the abundance of many adult butterflies, which has led to the establishment of similar schemes in many other countries. This promises the possibility of collaboration between European countries to establish an international index that will also allow comparison of butterfly population changes between different countries.

The 1970s was the decade when autecological studies of butterflies really expanded in Britain, ultimately to the benefit of many other insects as well as butterflies. In 1969 Jeremy Thomas began a doctoral research degree on the ecology of two hairstreak butterflies based at Monks Wood, which supports a large colony of the nationally rare Black Hairstreak (*Satyrium pruni*). His investigations of the Black and Brown Hairstreak (*Thecla betulae*) were written up (Thomas 1974) and proved influential in enabling these two elusive butterflies to be conserved by appropriate habitat protection and management. He then progressed to investigate the ecology of the endangered and enigmatic Large Blue butterfly (*Maculinea arion*) prior to its extinction in 1979, the knowledge that could have prevented the loss of the species from Britain came just too late to save the species, which succumbed to an unfortunate combination of site changes and weather factors after a long period of decline in the extent and quality of its habitat in South-west England. The association of the larvae of this butterfly with ants had long been known, but the missing crucial detail was that only one ant species (*Myrmica sabuleti*) was a suitable host, this ant being confined to hot micro-climates within very short, heavily-grazed turf. Knowledge of British ants was advanced greatly at Furzebrook Research Station by Michael Brian and colleagues from 1954 onwards (Brian 1977; Brian et al. 1977), a significant factor in enabling the Large Blue to be successfully studied and conserved. Ultimately, after much diligent work by Thomas and many others in the conservation agencies and voluntary organisations (Thomas 1999), the Large Blue was reintroduced to England from Swedish stock in 1984 and is now once more resident in England on more than 30 sites (Thomas et al. 2009). This conservation success demonstrates the importance of understanding the detailed requirements of threatened species before effective action can be taken and the need to begin research sufficiently early before a species has declined to the point of no return where chance or genetic effects can become intractable. It further demonstrated, when broader research was conducted at Large Blue sites, how a suite of invertebrates can benefit from habitat management designed to restore populations of a particularly specialist and demanding species that is declining rapidly in response to changes in its habitat.

Jack Dempster and colleagues investigated the status (Dempster et al. 1976) and population ecology of the Swallowtail butterfly (*Papilio machaon britannicus*) in the Norfolk Broads at a time when the butterfly had become extinct at a former well-known site, Wicken Fen NNR. Despite extensive planting in 1974 at Wicken Fen of the only larval food plant Milk Parsley (*Peucedanum palustre*), the relatively small area of suitable habitat, combined with drying out of the fen and its vegetation, resulted in a decline to extinction (Dempster and Hall 1980). The larger sites on the Norfolk Broads, where the food plant grew relatively taller in the mixed fen vegetation traditionally cut on rotation, sustained larger populations that moved around to exploit the food plant where it became available. Dempster later showed (Dempster 1991) that Swallowtails from Wicken had relatively smaller thorax size at the isolated Wicken site compared with those more mobile populations on the Norfolk Broads. There were similar differences over time for Large Blue, with smaller thorax size when populations were small and the species was in isolated and fragmented colonies. These findings have been influential in persuading butterfly conservationists and others that exemplary management of small and isolated sites is not sufficient in the long run; rather it is essential to take a much broader view at a landscape and countryside scale of how butterfly and other insect populations can be sustained through managing units between which movement and recolonisation can occur following local extinctions.

The publication in 1977 of 'A Nature Conservation Review' (NCR) edited by Derek Ratcliffe (Ratcliffe 1977) was a major achievement for biological conservation in Britain and more widely. The rigour displayed by Ratcliffe in establishing a stronger scientific basis for biological conservation, through defining explicit criteria for selecting important areas, was hugely influential across all biological disciplines, including invertebrate zoology. A strong team of specialists drawn from the former NC (divided at the time of publication between the newly-established NCC and the ITE) worked under Ratcliffe's leadership to identify 735 of the most important sites for protection within Great Britain. In volume 1, within the conservation of fauna section, it was recognised that sufficiently detailed survey and distribution data were only available for selected invertebrate groups (Lepidoptera, spiders in East Anglia, weevils in southern calcareous habitats, dragonflies in southern Britain and insects associated with calcareous scrub). These categories reflected the availability of extensive published accounts for Lepidoptera and the research interests of NC staff during the period when the Review was prepared. Invertebrate sites from these groups were integrated within site accounts in volume 2, based upon the analyses and rationales presented in volume 1.

The publication of the NCR stimulated further initiatives to identify in more detail important sites for groups of organisms, including the Invertebrate Site Register (ISR), another model being the a Register of Ornithological Sites compiled by the British Trust for Ornithology (BTO) from 1973 to 1977. Alan Stubbs initiated a pilot project for the ISR in Berkshire, South Region of NCC in 1978 carried out by Michael Parsons (who later worked on butterflies and their conservation in Papua New Guinea). The ISR later developed into a major NCC project for invertebrate conservation through the 1980s and is treated in more detail below in the account for that decade.

ITE was commissioned to survey invertebrates of sand dune and machair sites in Scotland (1976–1977), a project led by Colin Welch which documented the fauna of these remote and generally species-poor habitats and generated a series of contract reports. John Coulson and colleagues (Durham University) surveyed invertebrates of Pennine moorlands (1976–1978) with the aim of characterising the fauna associated with different conditions including peat and mineral soils, with and without flushing. This project was started at a time when moorlands were under increasing pressure from afforestation and drainage, hence information was required to manage these processes, together with the impacts of intensive sheep grazing and rotational heather burning. The work was published in several papers (for example, see Coulson and Butterfield 1985, 1986). Previously little-recorded species were found and the results showed what could be achieved by an extensive trapping survey in remote sites that are difficult for volunteer recorders to access and work in. Subsequently the success of the project led to the initiation of the Welsh Peatland Invertebrate Survey (WPIS) and the East Anglian Fen Survey (EAFIS), following discussions between CST invertebrate staff and Richard Lindsay, who later became leader of the CST Peatlands Team.

ITE was also contracted in 1976 to compile a Phytophagous Insect Data Bank, led by Lena Ward (ITE Furzebrook) with the aim of abstracting literature records of associations between insects and their host plants for use in management planning and surveying insects in different habitats. These data are now accessible online via the BRC website and a summary of the high-level patterns in the dataset was published by Ward and Spalding (1993). Full use of these complex data, with multiple links between insects and their host plants, has only become possible with improvements in database systems and then later with Internet tools.

NCC Council reviewed the work of the organisation in 1976–1977 and in November 1977 the Director Bob Boote announced a strengthening of the in-house scientific capacity by establishing units in England, Scotland and Wales to carry out survey and monitoring work and by increasing the staff complement of the CST. A reduction in the level of research commissioned by NCC from NERC was to be used to pay for the additional posts. Habitat networks were to be set up in NCC to facilitate more effective utilisation of scientific expertise throughout the organisation.

The England Field Unit within NCC was the only one to include an entomologist within its ranks, David Sheppard; Scotland and Wales continued to rely upon regionally-based surveys, carried out by contractors or volunteers, coupled with some projects led by CST. In February 1979 Ian McLean joined Alan Stubbs, based in London, in a support role within CST for terrestrial invertebrate conservation in Britain, initially dealing with site casework and organising surveys. In the same year Margaret Palmer joined Chris Newbold, based in Huntingdon, as the freshwater specialist in CST dealing with plants and invertebrates, with responsibilities for both still and flowing water habitats. The increased staff complement in NCC was followed by a period of tight financial restrictions, but resulted in a significantly higher level of in-house activity for terrestrial and freshwater invertebrate conservation in Britain at the start of the 1980s, a process that led eventually to the establishment of larger groups within the Chief Scientist Directorate (CSD: new title from 1984), based in NCC Peterborough from 1984 onwards.

In the late 1970s Alan Stubbs began to prepare guidance for NCC staff on invertebrate conservation, and the result was issued as an in-house document in the *CST Notes* series (Stubbs 1979). It was not made available outside NCC because the author's opinion on a variety of topics was given before internal policy agreement had been sought and achieved; also, some controversial issues were aired in a way that could not be shared externally. Nevertheless, the responses received were very positive overall and the document was influential within NCC and led to increasing levels of casework requests for advice on important sites (including NNRs) and threatened species from NCC regional staff. Other guidance for conserving invertebrates published by Stubbs in conjunction with external specialists at this time comprised well-illustrated leaflets on conserving bees and wasps (Else et al. 1978), molluscs (Kerney and Stubbs 1980) dragonflies (Chelmick et al. 1980) and butterflies (Stubbs 1981). These were popular publications that did much to improve understanding of the lifestyles and needs of these groups, both among conservationists and naturalists more generally.

On giving his Presidential Address to the British Entomological and Natural History Society (BENHS) (Stubbs 1982) Stubbs set out many of the concerns felt by traditional field entomologists in Britain at a time of rapid changes in the countryside coinciding with often strained relationships with conservation bodies who should have been their natural allies. In many respects this Address prepared the way for the ISR to communicate successfully with entomologists and thereby bring them into constructive dialogue with those working in NCC and other conservation bodies.

Three years later Stubbs took up the controversial topic of butterfly collecting, where views were becoming polarised and relationships strained between entomologists and conservationists over whether butterfly collecting could still be regarded as a legitimate activity (Stubbs 1985). A discussion meeting at the British

Entomological and Natural History Society in April 1985 concluded after a measured discussion that there was no sustainable argument for continued collecting of British butterflies in contrast to most other invertebrates where collecting is essential for accurate identification.

Ray Collier, based at NCC Inverness, is a good example of a member of NCC regional staff who combined his operational duties with conserving invertebrates. His regional responsibilities for managing NNRs were coupled with strong interests in studying and conserving butterflies and dragonflies. He wrote an account of conserving the Chequered Skipper butterfly (Collier 1986), as well as doing much to publicise interesting insects and their conservation requirements. Many other regional staff in the statutory agencies have walked butterfly transects, counted dragonfly exuviae and recorded a wide range of invertebrate groups, ranging from the popular and straightforward to the obscure and challenging. They have made an immense contribution to invertebrate conservation since the inception of the NC.

Freshwater conservation, including invertebrates, lagged behind terrestrial conservation for much of the early decades in the statutory conservation sector. The reasons for this include fragmented statutory responsibilities between the NC (and its successor agencies) and the complex range of public and private bodies responsible for water supply and quality in Britain. There was a strong constituency for angling interests in Britain, but otherwise there were fewer naturalists interested in freshwaters compared with terrestrial habitats and there was less recording of non-terrestrial invertebrates as a result.

3.5 The 1980s: The Growth of Invertebrate Conservation in NCC

The start of the 1980s was marked by the passing of the Wildlife and Countryside Act (1981), which was in many ways the result of increasing concerns at the ineffective protection for SSSIs against agricultural damage and declines in some charismatic species. While the measures resulted in some improvements to site protection, the process of SSSI renotification (which involved contacting all landowners to notify them of the special conservation interest on their land) took much longer than anticipated and in many respects sapped the vitality and productivity of NCC and its staff.

The Conservation of Wild Creatures and Wild Plants Act 1975 included one protected insect species, the Large Blue butterfly. The Wildlife and Countryside Act 1981 included *inter alia* 14 insects, 2 spiders and 3 molluscs largely based on submissions by the NCC, but also in response to interventions during the passage of the legislation through both Houses of Parliament. Entomologists were generally wary concerning species protection legislation, seeing the potential for long lists of protected species inhibiting field entomology, while at the same time not preventing continued habitat destruction through development and changes in land use. There was general acceptance that the list of protected species in the 1981 Act was justified in that taking specimens of the rare and threatened species listed on Schedule 5 would cause damage to these species, particularly bearing mind the recently announced extinction of the Large Blue butterfly (in 1979) where protection and ecological research had not come in time to save the species. Subsequently, the 5-yearly reviews of protected species have added considerably to the total number of protected plants and animals, including some species that are less easy to identify in the field. Nevertheless, the number of protected species in Britain remains considerably less than in many European countries and blanket listing of large numbers of any invertebrate group has not happened. Recognition of the importance of collecting invertebrates, to enable accurate identification of many cryptic and hard to identify species, has fortunately remained strong within the statutory conservation agencies and elsewhere in the conservation movement in Britain. The danger of large numbers of protected species constraining field entomology (and potentially creating a false perception that collecting is contrary to conservation) has also been avoided here.

The ISR recruited contract staff to collect and collate data for important invertebrate sites in 1980, with Mark Hadley and Caroline Peachey based at Belgrave Square responsible for England, Ian White (Edinburgh) dealing with Scotland and Jenny Rees (Bangor) covering Wales. In addition reviews of important sites for butterflies (Caroline Peachey) and moths (Mark Hadley) were initiated. Other staff who worked on the ISR at Belgrave Square in the early 1980s included Brian Eversham (among other tasks he prepared a report on invertebrate statuses correlating grid square occupancy with number of Vice-counties, before moving on to work at BRC), Andrew Foster (who also surveyed the Somerset Levels with Martin Drake for a year), Mark Parsons (a remarkably quick and accurate person for compiling data and preparing reports) and Roger Key who joined in 1984, shortly before the move to Peterborough, to work on northern England counties.

The NCC headquarters in Belgrave Square closed in late 1984, with CST and other staff transferring to Peterborough. At the same time the England headquarters moved to Peterborough to occupy a separate building nearby, where the England Field Unit (including entomologist David Sheppard) was based. The early years at Peterborough saw the England Field Unit continue their programme of surveys of SSSIs and areas of potential importance for flora and fauna.

In 1987 the first Insect Red Data Book for Britain (Shirt 1987) was published, having been overseen by a committee of specialists chaired by Michael Morris (ITE Furzebrook) and after a major editorial contribution by David Shirt. He had the complex task of bringing together the data sheets with supporting information from a wide variety of sources at a time when information technology was not available to assist with collating and editing. Subsequent reviews published by NCC and the Joint Nature Conservation Committee (JNCC) (See Appendix) have extended the taxonomic scope and coverage of this first Insect Red Data Book, although obtaining substantial staff resources to carry out and publish these reviews has been increasingly difficult since then. Two of the major insect orders that were tackled after the Insect Red Data Book were the Coleoptera (by Paul Hyman) and the Diptera (Steven Falk), followed by the Aculeate Hymenoptera (Steven Falk again); see Appendix.

These reviews enabled more detailed treatment of more species than had been possible with the limited resources available for the Insect Red Data Book, where voluntary contributions by leading specialists had enabled the first assessments of insects threatened by extinction to be made in Britain. Recently, JNCC has adopted a quality assurance role in the production of Red Lists to ensure that they meet the necessary scientific standards, with guidance available to specialist societies for carrying out status reviews and publication of endorsed Red Lists on the JNCC website.

A Red Data Book for invertebrates other than insects was compiled and edited by John Bratton in the last years of NCC, thereby helping to bring this diverse array of groups more securely into the mainstream of invertebrate conservation. Its publication (Bratton 1991) gave welcome publicity to many previously obscure, sometimes bizarre, invertebrates that are under threat of extinction. Since then the major societies in Britain concerned with these orders have both prospered in terms of their increasing membership and have also become more involved with conservation initiatives to a greater extent than previously.

The late 1970s into the 1980s saw an increased level of freshwater surveys by NCC and its contractors, with also the publication of guidance on conserving farm ponds and ditches (Palmer 1982). This was also a period when there was substantial agricultural change in many areas of grazing levels marshes, with conversion of previous grazing fields to arable cultivation and the consequent loss of plant and invertebrate interest in the intervening ditches. Drainage and arable conversion in the Somerset Levels and elsewhere resulted in sharp confrontations between NCC and farmers, and it was only later in the 1980s when payments for managing SSSIs for conservation became available that the tide turned and constructive relationships between NCC and farmers were restored.

Grazing levels marshes were a priority for survey during this period, with CST carrying out and commissioning surveys in conjunction with NCC regional staff; a good example of the detailed work that was carried out is the survey of invertebrates on the Somerset Levels (Drake et al. 1984). A further 1-year survey of the Gwent Levels was carried out by Martin Drake in 1985–1986, which brought knowledge of this area up to the standard of the Somerset Levels. In turn, this led eventually to a much better understanding of the flora and fauna of these marshes overall and how they should be sustained by sympathetic land management and rotational clearance of ditches in line with traditional practices. Another emphasis was on river faunas, with research commissioned by NCC resulting in the prediction of invertebrate communities using environmental measurements in streams (Wright et al. 1989).

During the 1980s there was rightly increasing attention paid to conservation of other wetlands in Britain. Peatland habitats in particular had suffered a long history of damage and destruction from farming and forestry, with the growth in afforestation of Scottish peatlands under favourable tax regimes a growing problem from the 1970s onwards. The NCC published a succession of reports, culminating in a thorough description of the Flow Country and its conservation interests (Lindsay et al. 1988). Following the Coulson research on Pennine moorland invertebrates from 1976 to 1978, it was realised that extensive surveys of peatland habitats were possible using a small professional team employing trapping techniques (but would be beyond the scope of what was possible using volunteers, given the huge logistical effort in sampling and identifying invertebrates from these remote and often dangerous areas). Hence a pilot study was started in Wales in 1986, which became the Welsh Peatland Invertebrate Survey (WPIS) from 1987 to 1989. Peter Holmes, David Boyce and David Reed used a combination of water traps and pitfall traps to sample the fauna of 118 sites, with the results written up as a series of reports and papers (Holmes et al. 1991, 1993a, b). They identified many groups themselves, but the value of the project was hugely increased by the contribution of numerous volunteer and professional entomologists who identified many additional groups. A total of 3020 species were identified, making a major contribution to our knowledge of this fauna, its association with different habitat conditions and geographical distribution. Later, from 1988 to 1990, Andrew Foster and Deborah Procter carried out an equivalent survey of 43 sites on the East Anglian Fens (Lott et al. 2002), which likewise relied extensively upon specialists to assist with identifications; again, their reward in some cases being the discovery of species new to Britain. They documented 1,676 species, again increasing our understanding of the fauna substantially from what is a better-recorded region historically. Ian McLean and Richard Lindsay had always hoped that it would be possible to initiate a similar 4–5 year project to characterise the invertebrate fauna of Scottish peatlands, including the Flow Country, but the demise of NCC and changed organisational priorities prevented this from coming to fruition.

In 1988–1989 Roger Morris and Mark Parsons carried out a detailed invertebrate survey of the internationally important coastal shingle site at Dungeness, Kent (Morris and Parsons 1993). This detailed survey of a major site of great significance to invertebrates related the invertebrates trapped to National Vegetation Classification plant communities. The survey enabled the population status and distribution of many threatened species to be determined, enabling impacts of proposed developments such as the proposed additional nuclear generating facility (Dungeness 'C'), further gravel extraction and the possible expansion of Lydd Airport to be assessed. The survey successfully described this outstanding invertebrate fauna in the context of the whole SSSI and with reference to other British coastal shingle sites.

When Stuart Ball joined the ISR team in 1985 his data management skills, coupled with his entomological experience, greatly improved data management processes for the ISR. The software that he developed enabled county reports to be compiled more efficiently and improved the speed and accuracy of handling and checking data. In due course he began to write the *Recorder* software (based extensively on his experience with handling ISR data), which is now a key part of compiling and sharing biological recording data for record centres, for recording schemes, for naturalists and as a route for feeding in data to the National Biodiversity Network (NBN). He published an overview of the ISR and its achievements (Ball 1994) that gave feedback to those many recorders who had submitted site and species data to the scheme up until that time.

Ian McLean succeeded Alan Stubbs in leading the Terrestrial Invertebrate Zoology Branch (TIZB) in 1987 and continued the trend of extending the scope of single species work, particularly where this was likely to enrich knowledge of habitat management, as well as establishing a programme of wetland surveys. Roger Key initiated the outward-looking programme of the *Invertebrate Conservation Roadshow* with the active participation of McLean and Ball among others within the Branch at Peterborough. By this time many more NCC staff had become familiar with invertebrate conservation issues, with the county ISR reports drawing attention to invertebrate conservation priorities throughout Britain, both on SSSIs and elsewhere. Experience had shown that although written guidance was essential for reference purposes, many NCC staff and those working for the NGOs (as staff or volunteers) would not have the confidence or motivation to become really involved with conserving invertebrates unless there was face to face contact to stimulate their interest and get them started. Starting in 1986 with the first events, these became a series of 1 day workshops, usually led by three TIZB staff, mainly for county wildlife trusts, but often with others ranging from landowners to staff from other agencies. A deliberate ploy was to try to bring together people from different backgrounds, both involved with conservation and those with a sceptical stance in order to engender lively debate and to get a diverse range of responses to the presentations. The TIZB staff learned at least as much from these events as the participants because they were exposed to a whole range of questions, issues and problems that so many people faced when trying to start conserving invertebrates. Between 1986 and 1993 there were 61 Roadshows attended by about 1642 people from at least 73 organisations, including all but one of the Wildlife Trusts. Since then similar events have been organised by several conservation bodies and a diverse range of specialists now lead these events in Britain.

The RSPB Wardens' Conference event at Nottingham in 1989 was a turning point in many respects for the acceptance of the need for RSPB to take account of invertebrates on RSPB reserves. Presentations by Stuart Ball, Roger Key and Ian McLean were warmly received and lively discussions over lunch raised many issues as to how best RSPB staff could take more account of conserving invertebrates in future. Until then a handful of keen and very competent RSPB staff (notably the late Maurice Waterhouse) had promoted invertebrate conservation within the organisation, but now they had the support and stimulus of others to help them from outside. RSPB continue to hold training events on invertebrate conservation for their staff and volunteers and now commission surveys and other research on invertebrates as part of their core programme of work, which includes managing sites to take account of conserving their invertebrate fauna.

One of the questions raised at every Roadshow event was "where is this all written down?" Apart from a few quickly assembled handouts, there was nothing suitable available at that time and so Peter Kirby (who had started by working on ISR county reports and gone on to review Neuroptera and Hemiptera) took on the task of preparing a guide to habitat management for invertebrates with funding from National Power and under contract to JNCC. The resulting book was first published by JNCC and RSPB in 1992, then when this sold out a revised edition was prepared (Kirby 2001). This has remained the best general guide to managing habitats for invertebrates in Britain; while knowledge continues to accumulate on improved management techniques for many groups and species, the broad scope and easy accessibility of the Kirby treatment make it ideal for those newly coming to the task of managing habitats for invertebrates.

Conservation research into the needs of threatened species continued principally with butterflies during the 1980s, although there were encouraging signs that resources could be obtained for other groups when a 3-year project by Andrew Cherrill at Imperial College on the ecology of the endangered Wart-biter Grasshopper, under the supervision of Valerie Brown, started in 1987. This demonstrated that this species needs a mosaic of short and long chalk grassland at a relatively fine scale to prosper, indicating that insects can have complex requirements that uniform management treatments, such as cutting, will not produce (Cherrill 1993).

After completing a Ph.D. on the Wood White butterfly at Cambridge University Martin Warren began to investigate the requirements of the Heath Fritillary (*Mellicta athalia*) in 1982 in a 3-year NCC-funded project with ITE involvement and participation in a joint partnership approach. It was evident that the Heath Fritillary was declining rapidly in both its Kent and South-west England sites, but his research came just in time to elucidate its requirements (Warren 1987a, b, c) and since then the species has fared better, though not without setbacks. Jeremy Thomas began research on declining woodland fritillaries under a 3-year contract to NCC in 1985 and as with his earlier research into the Large Blue, he discovered that woodland fritillaries were crucially dependent on hot micro-climates that appear after woodland coppicing or clearance so that the larvae can develop sufficiently rapidly on their Violet food plants, providing a severe challenge to woodland managers to create these conditions annually (Thomas and Snazell 1989). Thus, detailed research revealed an emerging pattern of many butterflies being warmth-loving insects, with females selecting food plants in specific situations that meet their micro-climatic requirements. Additional research carried out at ITE Monks Wood under contract to NCC (1985–1988) examining the affects of alternative management of woodland rides upon different invertebrate groups confirmed the benefits of active rotational management schemes and contributed to improved understanding of the needs of groups such as butterflies (Sparks et al. 1996).

After his success with the Heath Fritillary, Martin Warren was contracted by NCC (1985–1988) to review the major butterfly sites in southern England (where many of the rarest species and richest areas for butterflies are found) and he summarised his findings in a series of internal NCC county reports. The amount of information available from the many volunteer specialists who contributed, taken together with his own fieldwork using rapid spot counts to assess the strength of some of the major colonies of threatened species, resulted in the most detailed conservation overview of butterflies hitherto prepared for this area. The results were influential within NCC, and subsequently when published (Warren 1993a, b) within English Nature (EN), particularly with respect to the findings that SSSIs were not performing well in conserving threatened butterflies, largely because of the absence of sustained appropriate management to suit these insects on isolated sites, where generally small areas of suitable habitat require very careful treatment to maintain often small populations of specialist species. There was a degree of shock (and even a degree of denial) in some quarters because it had not been realised that the increased level of protection that SSSIs now enjoyed, following the passing of the 1981 Act, was not necessarily successful when it came to conserving more challenging and ecologically demanding groups such as butterflies. Again, this was an example of approaches that might be successfully conserving plants and habitats at a gross level would not work for more sensitive and complex invertebrate populations.

While butterflies had always been a popular groups of insects, rapidly becoming “honorary birds” in the minds of many naturalists and with an encouraging growth in membership of Butterfly Conservation to act as their supporters’ club, their fellow members of the order Lepidoptera, the moths, had been less fortunate. Nevertheless, moths were now sufficiently recognised for their ecological and conservation importance for NCC to appoint a moth ecologist on contract to investigate the requirements of four out of the five protected moths listed on Schedule 5 of the 1981 Wildlife and Countryside Act (the species not included was *Zygaena viciae*, known only from one remote site in Scotland). Paul Waring started work at NCC in 1987, and as well as working on ways of restoring the fortunes of those protected species on the edge of extinction, he also was alert to the possibility that suites of moths, in fenland and woodland habitats for example, might be threatened by inappropriate or lack of management. He initiated a National Recording Scheme for scarce moths (those occurring in less than 100 hectads), working closely with the network of Vice-county moth recorders and rapidly compiling much valuable data on these species. His work on the protected species at this time comprised the Barberry Carpet (*Pareulype berberata*), Black-veined Moth (*Siona lineata*), Essex Emerald (*Thetidia smaragdaria*), and Reddish Buff (*Acosmetia caliginosa*). Substantial progress was made with discovering the habitat requirements of these species and ensuring that appropriate management was put in place and sustained for these species, although the Essex Emerald had declined to near extinction by this time and despite Paul starting a captive rearing programme in 1987, eventually the moth became extinct in Britain. An account of the fight to save the Essex Emerald from extinction was published later (Waring 2005), while the other protected moths, together with priority species identified by UK BAP, later benefited from practical conservation measures under the EN Species Recovery Programme, for an example see the case study of the Barberry Carpet (Waring 2004). Since then Butterfly Conservation has become much more active in moth conservation, with staff specialising in conserving moths as well as butterflies and much of the work that Waring initiated is now taken forward in partnerships between Butterfly Conservation and the country conservation agencies, often in collaboration with local bodies.

The only published synopsis of ISR information for a geographical area is the account by Adrian Fowles of important sites and invertebrate species in Wales (Fowles 1994a). This had the aim of summarising the highlights of the Welsh fauna for local and visiting entomologists as well as giving an overview of the known priorities for conservationists to be aware of, and to take action for, when needed. Originally, equivalent volumes for England and Scotland were planned but following the reorganisation of NCC this was not achieved. The book by Fowles summarised not only the results for the ISR and published literature, but also set them in their historical, geological and habitat context; this approach would be worth attempting for other parts of Britain, and indeed internationally, in order to improve understanding of invertebrate conservation amongst both entomologists and conservationists as a whole.

A good example of the synergy that was possible when people with different backgrounds and interests come together was the symposium paper by Martin Warren and Roger Key (1991) that contrasted the habitat requirements and conservation problems facing insects associated with early successional stages in woodlands and those in climax woodlands or in post-mature trees. Further collaboration at about this time between Warren and Rob Fuller of the BTO resulted in two popular NCC booklets on woodland management that combined their respective experience of woodland butterflies and birds (Warren and Fuller 1990; Fuller and Warren 1990). In his Presidential Address to the BENHS Ian McLean summarised some of the habitat management principles that had emerged from recent studies on a range of insect groups for a general audience of field entomologists (McLean 1990). Another theme that was discussed here was the role that invertebrate conservation can play in refreshing and enriching biological conservation as a whole, because invertebrates are such challenging organisms to work with!

By the end of the decade the England Field Unit entomologists David Sheppard and Martin Drake had undertaken a substantial number of invertebrate surveys, listed by Palmer (1992). These ranged from strategic baseline surveys (such as assessing the results of transplanting Magnesian Limestone grassland at Thrislington Plantation, Durham: see Sheppard 1990) amounting to 12 major studies; 14 moderate effort surveys; 31 rapid surveys or desk studies.

The last large scale survey funded by the NCC in a consortium partnership with Fisons PLC, WWF, Teredo Petroleum Ltd, and Lincolnshire and Yorkshire Wildlife trusts, was the year long survey by David Heaver of Thorne and Hatfield Moors SSSI (Heaver and Eversham 1991), at that time being subject to intensive peat milling; by the time the survey had completed the NCC in England had become EN.

3.6 The 1990s: New Agencies and Fresh Challenges

The start of the 1990s saw the division of the NCC into separate agencies for each of the countries within Britain, English Nature from NCC England, the Countryside Council for Wales, CCW (formed from NCC in Wales and the Countryside Commission in Wales) and NCC Scotland (subsequently merged with the Countryside Commission for Scotland to form Scottish Natural Heritage, SNH, in 1991). A small separate body, the JNCC, was established for coordinating GB/UK approaches on international conservation issues and for setting standards and delivering advice on behalf of all the country agencies where this was mutually agreed.

The impact of devolution reached nature conservation about 15 years in advance of political devolution for Scotland and Wales, with the establishment of the new country agencies. While there may well have been an intention by the then Secretary of State for the Environment (Nicholas Ridley) to "divide and rule" the former NCC, which during the 1980s had sought to protect the Flow Country in northern Scotland from extensive drainage and conifer planting, but whatever the motives and intentions the consequences for conservation were more positive than might have been anticipated. The new agencies were able to work with their respective political masters ahead of the establishment of devolved elected assemblies and in many respects the JNCC was pre-adapted to cope with the new devolved political realities.

After their inception, each of the new agencies began to develop distinct approaches to tackling the priorities and special challenges facing their own faunas. The different numbers of invertebrate specialists remaining in each country and in JNCC also affected the quantity of work that could be done; overall there was a reduction in numbers of entomologists as specialist staff compared with the latter years of the previous decade, although improving computer systems and data management techniques helped to make the acquisition, management and use of invertebrate data quicker and easier.

The ISR as an active project largely ceased when the NCC was split, although some site and species data continued to be added, separately in each country, from submissions by entomologists and from the published literature. Increasingly, the focus became species recovery projects and on implementing the UK Biodiversity Action Plan (Anon. 1994). With the development of the species recovery approach there were fresh opportunities for working proactively with the media to show a positive and constructive face to biodiversity conservation, rather than the emphasis being to oppose destructive developments that damage sites and species (although such damaging developments continued to be contested by the statutory sector and by NGOs). Within England up to 10% of the Species Recovery Programme (SRP) budget was available for work on species not listed on the UK Biodiversity Action Plan, with successes achieved for species such as the Ladybird Spider (*Eresus sandaliatus*), Lundy Cabbage Flea Beetle (*Psylliodes luridipennis*) and Field Cricket (*Gryllus campestris*).

The UK Biodiversity Action Plan (Anon. 1994) has undoubtedly given new impetus to many aspects of conserving UK biodiversity, including invertebrates. It originated as the UK response to the Convention on Biological Diversity (CBD), the UK being a signatory to the CBD at Rio de Janeiro in 1992. It has a long and complex history and there is only room here for a very brief summary of this major programme that has occupied much time for those working within and outside the statutory conservation agencies. Since its inception there have been some differences of view in defining those habitats and species that are to be priorities for conservation action, as well as difficulties with integrating the action for conserving threatened species within a broader framework for habitat conservation. Nevertheless, the Plan has resulted in much new energy and resources becoming available for conserving invertebrates, as well as other wildlife, and has engaged many new partners outside the conservation sector in becoming involved with conserving wildlife in the UK. The principal source of information about the history of the UK Biodiversity Action Plan, as well as progress in meeting the targets agreed for habitats and species, remains the website maintained by JNCC (http://jncc.defra.gov.uk/default.aspx?page=5155), from where pages can be accessed listing priority habitats and species, including invertebrates. After the 2007 review, there are 1,150 priority species, including 349 insects, 31 arachnids 19 molluscs and 14 other invertebrates.

The Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, generally known as the *Habitats Directive*, was adopted in 1992 by members of the European Union to implement the Bern Convention. A summary of the Directive and its implementation is given on the JNCC website (http://jncc.defra.gov.uk/page-1374). Work to implement the Habitats Directive in the UK has taken a substantial amount of time for staff in the statutory conservation agencies since 1992, in selecting sites (Special Areas of Conservation, or SACs) to represent the habitats and species to be conserved, in taking measures to conserve the interests represented on SACs and in meeting obligations to report to the European Union on the progress made. The invertebrate species listed on the Annexes of the Directive are derived from the original Bern Convention and represent a small selection of those species of European significance present in Britain and the UK, consisting of six molluscs, five insects and one crayfish species. As with implementing many national and international legal instruments for conserving biodiversity, there have also been many practical difficulties with interpreting the terms used (in the case of the Directive, the term 'favourable conservation status' has perhaps been particularly problematic), as well as with integrating the actions taken with other major lines of work, such as the UK Biodiversity Action Plan. There has been significant survey work commissioned by each of the country agencies to assess the distribution and population status of invertebrates listed on the Directive, while the JNCC in conjunction with the country agencies has compiled summaries of the information available on a consistent level, which can be retrieved from: http://jncc.defra.gov.uk/Publications/JNCC312/UK_species_list.asp.

One of the hitherto neglected habitats for invertebrates that has received increasing attention in recent decades are those sites containing ancient or veteran trees often with standing and fallen dead wood. Alan Stubbs drew attention to the significance of the associated invertebrate fauna and its lack of attention by conservationists in a pioneering paper (Stubbs 1972) that began the process of raising awareness that the best examples of this fauna were confined to relatively few sites and moreover they were extremely vulnerable to many routine woodland or parkland management operations that damaged or removed veteran trees. In the 1970s Paul Harding carried out surveys of pasture woodlands under contract to NCC, the results were later summarised in Harding and Rose (1986). During the 1980s and 1990s entomologists were in the vanguard of efforts to improve the conservation of veteran trees and their associated wildlife alongside mycologists and lichenologists. The term 'saproxylic invertebrates' became a familiar phrase as shorthand for the immensely rich fauna associated with many specialised niches on veteran trees. Two conferences were held, at Burnham Beeches in 1991 and at Epping Forest in 1993 (Read 1991, 1996). These events brought together leading specialists from a wide range of relevant biological disciplines to discuss how to improve the protection and management of veteran trees in parklands, ancient woodlands and elsewhere.

These conferences also led to the formation of the Ancient Tree Forum in 1993, which body has done much subsequently to raise the profile of veteran trees and their conservation needs. Later guidance was published by EN on managing veteran trees (Read 2000), while agency entomologists have contributed to developing methods for evaluating the saproxylic fauna at sites in Britain (for example, see Fowles et al. 1999) and with reviewing the conservation of pasture woodland (for instance, Kirby et al. 1995). There are now many more naturalists and conservationists who are aware of the fragility and importance of saproxylic invertebrates and many more people who support measures to conserve these species where they have managed to survive.

In EN invertebrate conservation was led by Roger Key, supported by Martin Drake and David Sheppard. They were very active in leading many projects within the EN SRP, continued Roadshows and training events for EN staff and others, as well as establishing collaborative research projects with universities (including some NERC awards under the CASE programme) on invertebrate conservation topics. Between 1995 and 2005 a total of 19 Masters and Ph.D. projects were carried out, with many on UK Biodiversity Action Plan priority species, including Ross Piper's research on *Cryptocephalus* leaf beetles (Piper 2002; Piper and Compton 2003) and Daniel Chapman's investigations of *Chrysolina graminis* near York (Chapman et al. 2006, 2007). All these joint projects did much to engage the academic community with practical invertebrate conservation issues as well as generating new data, information and guidance for those conserving threatened species or carrying out conservation management for sites with significant invertebrate interest. The growth in the use of molecular techniques in biology was also reflected in their increased deployment by invertebrate conservation projects initiated by the statutory agencies during the 1990s. At the same time a project to evaluate the taxonomic standing of alleged endemic species in England with the Natural History Museum showed that few of these species could be confirmed as true endemics (Hammond 1996). One species that 'survived' this process was the Lundy Cabbage Flea Beetle *Psylliodes luridipennis*, which had detailed studies of its conservation and evolutionary ecology carried out at Leeds University (see Compton et al. 2002). These investigations secured the future of the beetle, as well as revealing an additional endemic weevil in the genus *Ceutorhynchus* (as yet un-named), associated with the same plant, with the additional benefit of advancing the science of suppressing *Rhododendron*, an alien invasive species on Lundy Island.

There was a significant volume of site safeguard work carried out in conjunction with regional staff, including Ridham Marshes, Rainham Marshes (several times), Dogsthorpe Star Pit and Dungeness. They also published the Invertebrate Conservation Strategy for England (Key et al. 2000), which reviewed the scope of work in England and future options for developing this further.

Among the neglected habitats of significance for invertebrates, bare ground has long been paramount in terms of its vulnerability to well-meaning, but terminally damaging, initiatives to cover every possible area on sites with a blanket of vegetation. Key (2000) discussed the issues and offered advice in an article to redress the balance against the perceived need to avoid bare ground on conservation sites and elsewhere. This requirement is now well described in the internal Natural England (NE) Common Standards Guidance for invertebrates on SSSIs (updated in 2008), which uses a system of habitat surface definitions to both set and monitor site structure, between direct invertebrate surveys. Other neglected invertebrate habitats that received survey attention in England since 1990 include river shingle deposits, coastal cliffs and veteran trees, with the results used for site safeguard and improved management.

Roger Key became extensively involved with the media, including TV, radio and printed outlets, with the aims of increasing interest in invertebrates and their conservation. He had regular involvement with BBC1 and BBC2 countryside TV programmes and on Radio 4 broadcasts 'The Natural History Programme' and 'Living Planet'. Roger Key and his colleagues also became involved with many events for children (again to stimulate interest and to counter hostility towards invertebrates) including the now commonplace 'Minibeast Safaris' and 'Bioblitz Events'. EN also engaged with a wider public at events such as the Rutland Bird Fair and the BBC 'Gardener's World Live' Garden Show at the National Exhibition Centre at Birmingham, where garden invertebrates was always a major theme. This led indirectly to the creation of a series of 15 titles, three of which (*Butterflies and Moths in Your Garden*, *Dragonflies in Your Garden* and the most popular of all *Minibeasts in Your Garden*) were on invertebrates.

David Phillips joined SNH in 1993 as invertebrate ecologist and over the next 9 years worked assiduously and with infectious enthusiasm to conserve Scotland's fauna. He used the media frequently to raise awareness of Scotland's special invertebrates, combined an awareness of the need to manage habitats for assemblages of invertebrates with the requirement to take special measures for threatened specialist species and he strengthened SNH partnerships with organisations such as Butterfly Conservation and the Royal Scottish Museum in order to deliver more invertebrate conservation in Scotland. His special interests included parasitoid Hymenoptera, ants and bumblebees and he was proficient in using modern information systems. He died of a brain tumour in 2004 at the age of 39. He was succeeded by Athayde Tonhasca as the invertebrate specialist within SNH. In CCW Adrian Fowles and Mike Howe commissioned research on UK BAP and other priority species in Wales and worked to increase information available about the extent of major invertebrate habitats, including parklands (Fowles 1997; Fowles et al. 1999), river shingle and soft rock cliffs (Howe 2003). Collaborative research with Universities led to the establishment of seven Ph.D. studies on invertebrate conservation issues and week-long training courses in Habitat Management for Invertebrates were held for several years in conjunction with Snowdonia National Park Authority and EN. Reviews of invertebrate groups in Wales were produced, with Arachnida (Fowles 1994b) and Aculeate Hymenoptera (Fowles 1996) followed later by Diptera: Brachycera (Howe 2002) and Hemiptera: Heteroptera (Howe 2004). Wales supports important populations of species such as the Marsh Fritillary butterfly (*Euphydryas aurinia*) and the Hornet robberfly (*Asilus crabroniformis*), whose populations were monitored or assessed where possible.

3.7 The New Millennium: A Changing Conservation Agenda

Biodiversity conservation in the new millennium has become increasingly international in outlook and focus in Britain and elsewhere. In many respects this is a response to more European environmental legislation setting the targets and direction for conservation via the major Directives, coupled with an increasing realisation that the impacts of human population growth and resulting impacts on natural resources and ecosystems need to be addressed jointly by many nations. For specialised aspects of biodiversity conservation, including conserving British invertebrates, the challenge has been to build on and apply the knowledge gained in recent decades in ways that improve the prospects for our fauna and at the same time are seen as relevant and significant in the face of many competing demands for funding in the public sector and elsewhere. In the decade preceding 2011 fewer entomologists have been employed in the statutory conservation agencies in specialist roles directed towards solely conserving invertebrates, instead their skills are being used in multi-disciplinary projects and in using the results of surveying and monitoring invertebrates to assess what is happening to Britain's invertebrates overall. It remains a huge challenge to detect trends for invertebrates and then to decide how best to respond to the causes of declines in conjunction with tackling the pressures on plants, fungi and vertebrates.

The growth of the National Biodiversity Network since 2000 has enabled the results for invertebrate national recording schemes and many other surveys to be made available quickly and easily via the Internet through the NBN Gateway (http://data.nbn.org.uk/) alongside other wildlife. The development of the necessary software to carry out these tasks has been carried out jointly by CEH and JNCC, with further development of the *Recorder* biological recording software (Stuart Ball having a major role here) being an additional project required to set data standards and enable large datasets to be compiled and delivered consistently via the Internet and other routes. The large number of invertebrate taxa has meant that skills acquired to manage complex invertebrate data are extremely relevant to the current era of mass data delivery via the Internet.

Within JNCC the data and information derived from the BRC partnership between CEH and JNCC, together with results from projects such as the UK Butterfly Monitoring Scheme, have been major contributors towards compiling sets of wildlife statistics and UK Biodiversity Indicators, with Stuart Ball developing analytical techniques and conducting analyses in conjunction with partners and contractors. Invertebrate distribution atlases published by BRC in recent years under the partnership with JNCC have a wider scope and enriched content than ever before, with more refined analyses coupled with colourful presentation of results. In addition, larger datasets are now being accumulated from the expanding pool of volunteer recorders. An outstanding example is *The Millennium Atlas of Butterflies in Britain and Ireland* (Asher et al. 2001), whose content and presentation rivals any ornithological volume. Such datasets are now also online via the NBN Gateway.

The need for a classification system for invertebrate habitats to act as a framework for survey and monitoring projects led EN to develop ISIS under the direction of Jonathan Webb, with an initial publication setting out the development of this work (Webb and Lott 2006). Contractors, including the late Derek Lott and Martin Drake, were responsible for developing the methods using original datasets. A comprehensive account of survey methods for terrestrial and freshwater invertebrates for the purposes of conservation evaluation was subsequently published (Drake et al. 2007), which makes use of the ISIS framework, as well as giving guidance for Common Standards Monitoring of SSSIs, descriptions of practical field and laboratory techniques and help with planning and carrying out surveys.

Organisational change continued in the new millennium, with EN merging with elements from the Countryside Agency and the Rural Development Service to become Natural England (NE) in 2006. After EN became NE, David Heaver succeeded Roger Key in leading invertebrate conservation within England. Priority work has included habitat feature recognition and FCS monitoring of SSSI habitats for their value to invertebrates, continued improvement of ISIS, several collaborative projects with external organisations including the Riverfly Partnership, which aims to protect water quality of rivers and conserve their riverfly inhabitants (caddisflies, mayflies, stoneflies), in addition to continuing Species Recovery projects on species such as Ladybird Spider, Fen Raft Spider a suite of bees, ants and wasps, and butterfly and moth work with Butterfly Conservation.

Athayde Tonhasca in SNH has contributed to the development of the SNH Species Action Framework, with the following invertebrates currently listed for priority action: Freshwater Pearl Mussel (*Margaritifera margaritifera*), Great Yellow Bumblebee (*Bombus distinguendus*), Marsh Fritillary butterfly (*Euphydryas aurinia*), Pearl-bordered Fritillary butterfly (*Boloria euphrosyne*), Pine Hoverfly (*Blera fallax*), Slender Scotch Burnet moth (*Zygaena loti scotica*). Partnership work has continued with Butterfly Conservation in Scotland on conserving priority species, as well as strengthening the volunteer base, as well as with Buglife and others on developing *A strategy for Scottish invertebrate conservation* (Macadam and Rotheray 2009), which was launched early in 2009. Other projects include an evaluation of the conservation value of artificial nests for the UK BAP priority bee *Osmia uncinata*, studies of five UK BAP priority Diptera species in Scotland for which there is limited information on their population status and habitat condition and where improved knowledge is required for their successful conservation, and a project to improve surveillance for priority terrestrial invertebrates in Scotland using expertise available from external specialists.

Adrian Fowles and Mike Howe have remained the invertebrate specialists in CCW during the past decade and their emphasis has been on a combination of conserving priority invertebrate sites and species throughout Wales, often in partnership with the voluntary sector. A shift in emphasis to recognise the importance of landscape-scale conservation for species such as the Marsh Fritillary has resulted in a major assessment of the habitat resource for this species in Wales (Fowles and Smith 2006; Fowles 2011). Work has continued on soft rock cliffs (Howe et al. 2008), sand dunes (Howe et al. 2010), exposed river sediments (Sadler et al. 2004; Bates et al. 2007) and on UK BAP priority species. Much research has also been carried out on the development of Common Standards Monitoring for invertebrate features on

SSSIs, with over 40 species assessed and assemblage monitoring for wetlands, peatlands and sand dunes initiated.

Over the past decade each of the statutory conservation agencies have been active in establishing strong and effective working partnerships with the voluntary sector organisations working on invertebrate conservation, including British Arachnological Society, Buglife – The Invertebrate Conservation Trust, Bumblebee Conservation Trust, Butterfly Conservation, Conchological Society of Great Britain and Ireland, Hymettus, The Aquatic Coleoptera Conservation Trust, The Riverfly Partnership and The British Dragonfly Society. Such links and partnerships will encourage invertebrate conservation in the voluntary sector to continue to grow and receive more public support at a time when public sector organisations are facing severe budget cuts. It seems likely that these trends will continue, with the government sector working more closely with charitable bodies in partnership to conserve invertebrates in Britain, although deep funding cuts in 2010–2011 have made this difficult to sustain.

Increasing availability of invertebrate species data via the Internet, notably through the NBN Gateway, is a valuable asset for invertebrate conservation in the statutory agencies and for the voluntary sector. There is the pressing need to improve data quality, given that some datasets are being made available online without the validation and verification that was previously carried out by national recording schemes, but overall the extent and coverage of data being made available is a tremendous advance for invertebrate conservation.

There is now increasing attention given to conserving biodiversity, including invertebrates, at a landscape scale so that SSSIs and other important sites are viewed in a wider geographical context that will improve their resilience to the effects of climate change and human impacts. These views have been put forward in the independent review in England chaired by Sir John Lawton (Lawton et al. 2010), which gives a strong emphasis to habitat recreation and restoration as well as to re-establishing ecological processes and ecosystem services. The fate of many invertebrate species will depend upon how successfully this philosophy can be translated into action.

3.8 Conclusions

The history of invertebrate conservation within the British statutory conservation agencies has been of some hard-won successes in the face of many adverse changes in the countryside and against strong competition for resources from other sectors. Starting from a low base, with little real understanding of the ecological principles involved, a combination of high quality scientific research with acute natural history observation has brought a much better understanding of what needs to be done to conserve many invertebrate populations. The failures that have occurred, including the extinction from Britain of some high profile species and declines in many others, are worthy of more attention to reduce their likelihood in future.

There remain real challenges in putting our hard-won knowledge into practice on the ground, as well as in finding better ways to link up with other biological disciplines to prevent the continual erosion of the extent and quality of our remaining high-quality habitats. Although the special needs of invertebrates are more widely accepted than ever before within the world of biodiversity conservation, there is still much to be done to convince society as a whole of the importance of invertebrates and the need for their conservation.

The growth and successes of invertebrate conservation make it harder than ever to gain an overview of the subject and to summarise the principal events and those responsible for advancing knowledge and applying the results on the ground. Nevertheless, we should be confident that invertebrate conservation will continue to thrive and not only be successful in conserving invertebrates, but will also refresh and revitalise biological conservation more broadly: after all, if we can succeed in conserving rich and diverse invertebrate assemblages for future generations to enjoy, then we should be able to sustain all the other biological groups with which they interact.

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Appendix: Published Invertebrate National Species Reviews, Chronological Sequence

Bratton JH (1990) A review of the scarce and threatened Ephemeroptera and Plecoptera of Great Britain. Res Surv Nat Conserv 29:1–40

Merrett P (1990) A review of the nationally notable spiders of Great Britain. Contract Surveys, vol 127. Nature Conservancy Council, Peterborough

Wallace ID (1991) A review of the Trichoptera of Great Britain. Res Surv Nat Conserv 32:1–61

Kirby P (1991) A review of the scarcer Neuroptera of Great Britain. Res Surv Nat Conserv 34:1–30

Falk SJ (1991) A review of the scarce and threatened bees, wasps and ants of Great Britain. Res Surv Nat Conserv 35:1–344

Falk SJ (1991) A review of the scarce and threatened flies of Great Britain. Part 1. Res Surv Nat Conserv 39:1–194

Kirby P (1992) A review of the scarce and threatened Hemiptera of Great Britain. UK Nat Conserv 2:1–267

Hyman PS (revised and updated by Parsons MS) (1992) A review of the scarce and threatened beetles of Great Britain Part 1. UK Nat Conserv 3:1–484

Parsons MS (1993) A review of the scarce and threatened pyralid moths of Great Britain. UK Nat Conserv 11:1–98

Hyman PS (revised and updated by Parsons MS) (1994) A review of the scarce and threatened Coleoptera of Great Britain. Part 2. UK Nat Conserv 12:1–248

Parsons MS (1995) A review of the scarce and threatened ethmiinae, stathmopodine and gelechiid moths of Great Britain. UK Nat Conserv 16:1–130

Falk SJ, Chandler P (2005) A review of the scarce and threatened flies of Great Britain. Part 2: Nematocera and Aschiza. Species Status 2:1–189

Falk SJ, Crossley R (2005) A Review of the scarce and threatened flies of Great Britain. Part 3 Empidoidea. Species Status 3:1–134

Daguet C, French G, Taylor P (eds) (2008) The Odonata Red Data List for Great Britain. Species Status Assessment No. 11:1–34

Fox R, Warren MS, Brereton T (2010) The butterfly red list for Britain. Species Status Assessment No. 12:1–31

Foster GN (2010) A review of the scarce and threatened Coleoptera of Great Britain. Part 3: Water beetles. Species Status 1:1–143

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Chapter 4
The Development of Buglife – The Invertebrate Conservation Trust

Alan Stubbs and Matt Shardlow

4.1 Pro-Genesis – The UK Response to the Biodiversity Convention

The Rio Earth Summit in 1992 was an international landmark in commitment to biodiversity – a new term that the politicians readily accepted to mean all organisms, including the tiny and obscure. The resulting Biodiversity Convention was a major breakthrough for invertebrate conservation. It radically reduced the time and energy needed to convince others that invertebrates were worthy of conservation attention; now bugs were 'wildlife' as well.

According to anecdote, while in Brazil for the summit the British Prime Minister John Major and Michael Howard (the then Secretary of State for the Environment) flew over the Amazon rainforest and were shocked by what they saw. On their return John Major established an inter-departmental steering group to secure cross Government commitment to saving biodiversity. However, despite UK Government rhetoric that it would lead the world on biodiversity conservation, there was widespread concern that the Government's conservation agencies, that might be expected to develop and implement a thorough action plan, were not showing the necessary enthusiasm. The agencies had recently been reorganised and were still disoriented from being split from one UK body, the Nature Conservancy Council, into three country bodies and an over arching committee, English Nature, Countryside Council for Wales (CCW), Scottish Natural Heritage and Joint Nature Conservation Committee (JNCC) (McLean and Key, this volume Chap. 3). In addition the European Habitats Directive had been put into legislation in 1992 and some of the more able minds in the agencies were focused on converting the European level legislation into implementable

A. Stubbs • M. Shardlow (✉)
Buglife – The Invertebrate Conservation Trust, First Floor, 90 Bridge Street,
Peterborough PE1 1DY, UK
e-mail: alan.stubbs@buglife.org.uk; Matt.Shardlow@Buglife.org.uk

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national legislation. The need to respond to the more aspirational and less enforceable Biodiversity Convention did not seem to be top of their priorities.

The Biodiversity Convention required parties to develop national plans for the conservation and sustainable use of biological diversity, but there was debate about how this should be applied. The tensions were clear at a 2 day seminar in May 1993 'Action for Biodiversity in the UK' (Wright et al. 1993). Graham Wynne, Conservation Director of the Royal Society for the Protection of Birds (RSPB), set out a vision for an approach based on targets and action plans for both rare and common but seriously declining, species and habitats. Many Government agency staff were unconvinced and English Nature's Chief Executive, Derek Langslow's summing-up indicated that species-based targets might work for some species, but not for invertebrates.

Realising that there was a risk that a really good opportunity to improve conservation activities might be lost, six charities – the RSPB, the Wildlife Trusts, World Wildlife Fund, Friends of the Earth, Plantlife and Butterfly Conservation (BC) – came together under the banner of 'Biodiversity Challenge'. Their vision was clear, the UK Biodiversity Action Plan should be centered about two lists, one of the habitats in greatest need of protection, enhancement and restoration, and one of the species in greatest need of conservation action. Previous Government biodiversity initiatives had been plagued by the non-committal language of aspirational targets – "endeavour to", "where possible", "take steps". This had created situations where responsibility for achieving the outcome was not allocated. In the case of the lists, each habitat and species should have a set of biological and/or knowledge targets (objectives) and the actions needed to meet these targets should be allocated to delivery bodies. Focusing conservation towards the species and habitats in greatest difficulty would provide a strong direction that would address the key issues impacting on wildlife.

At the time Butterfly Conservation (BC), based in Dorset, had just one member of conservation staff (Martin Warren), and then only encompassed butterflies (Warren, Chap. 6). As a member of the BC Conservation Committee geographically close to the RSPB HQ, Alan Stubbs was asked to represent BC at the first 'Biodiversity Challenge' meeting. Alan ended up covering all invertebrates; coordinating the input of invertebrate study societies and individual experts to define an initial list of threatened species; write example species action plans; and ensure, as well as possible, that invertebrate needs were accommodated in habitat action plans. The task was undertaken with vigour and in December 1993, just six hectic months after it was conceived, they published 'The Biodiversity Challenge: An Agenda for Conservation Action in the UK' (Wynne et al. 1993). The document set out the vision and included annotated example lists of species and habitats that would be deserving of such an approach.

The Government responded in mid-1994 when the inter-department steering group produced 'Biodiversity: The UK Action Plan' (DoE 1994). The document was a thorough exercise and committed to prepare species action plans for 90% of the presently known globally threatened species and threatened endemic species within the next 10 years. Although this list would be rather short, the document was recognised as "a tentative though valuable step in the right direction" by the Biodiversity Challenge group in an expanded second edition of the 'Biodiversity Challenge' report produced in early 1995, and now including many worked-up species and habitat action plans (Wynne et al. 1995).

Despite the hesitancy of the Government's own agencies and some opposition from the Ministry of Agriculture, Fisheries and Food (MAFF), John Gummer MP, the Secretary of State for the Environment, and senior civil servants John Plowman and Roger Bendall, were keen on partnership and favoured the target and plan approach. They established a new partnership, the UK Biodiversity Steering Group to bring together all the Government and non-government players to agree lists and plans and oversee implementation, monitoring and reporting. In December 1995 the approach was officially set in stone when the 'Biodiversity: The UK Steering Group Report' (1995a, b) was published containing dozens of species and habitat action plans with targets and a list of species meeting criteria related to decline and international significance that would get species action plans in subsequent tranches. (Although as a rear-guard action the agencies did manage to demote some of the species and habitats to a 'statement' category, these unfortunates would never be set targets).

4.2 A New Beginning

The work of the Biodiversity Challenge group had revealed an issue of some concern to existing wildlife charities. The absence of a national wildlife NGO focusing specifically on the conservation of invertebrates was a significant weakness. Understanding a landscape of small specialist invertebrate societies, recording schemes and individual experts was hard in itself, but focusing and coordinating their almost wholly voluntary efforts on strategic conservation efforts was both a Herculean task and a fragile artwork.

The Biodiversity Action Plan process also gave hope to members of invertebrate societies who were concerned about the declines they observed in invertebrate populations. Perhaps times were changing; perhaps there was an opportunity now to put the conservation of the animals they loved on the national agenda.

Under the auspices of the Joint Committee for the Conservation of British Invertebrates (JCCBI) Alan Stubbs arranged three conferences with the banner 'Unity of Purpose'. The title highlighted that the study of invertebrates was disparate among many societies, recording schemes and conservation bodies: without a unifying common purpose, they would have little influence.

The JCCBI had formed in 1968 as a committee linking together all the entomological schemes and societies (Morris and Cheesman, Chap. 2). While it had provided a good forum for discussion and the development of joint positions between organisations on issues such as collecting ethics and agreeing early lists of endangered species, the committee structure and lack of staff meant that processes were slow and the capacity to take action was very limited.

The first 'Unity of Purpose' conference in 1996 outlined the problems to be addressed (Brooks 1997). While there was consensus that more needed to be done to conserve invertebrates, hardly anyone wanted a new body, and none of the existing Non-Governmental Organisations (NGOs) would pick up the baton either.

Generalist wildlife conservation organisations would campaign for water voles and otters, but not for obscure beetles, while specialist societies conserving birds, plants or Lepidoptera, would not expand their primary focus. At the same time, none of the three national entomological societies would take on conservation employees, or for that matter all invertebrates.

The second conference in 1997 investigated the options available to take invertebrate conservation forward (Brooks and Nellist 1998). A poll at the end of the conference showed that about half the attendees accepted that a new invertebrate conservation focused organisation was the only way forward.

A committee was established to look more closely at the case for a new organisation; a JCCBI paper was produced in 2000 and circulated around the entomological and conservation organisations to garner opinions and support. A board-in-waiting was established to draw up in detail the purpose and means of governance and operation of the new body.

When a legacy became available for invertebrate conservation a company, The Invertebrate Conservation Trust, was registered in December 2000. An unusual structure was formulated, in that the company would consist of Trustees and invertebrate and conservation organisations; five trustees and 20 leading NGOs formed the company. Initially, everything depended on the small trustee board of entomologists willing to take an active role and responsibility – Tony Pickles, Treasurer, a professional accountant, member of the British Entomological and Natural History Society (BENHS) and a lepidopterist; David Lonsdale, Secretary, member of the Amateur Entomologists Society, editor of the Society's Conservation News and co-author of its book on insect conservation (Fry and Lonsdale 1991); Stephen Miles, Chairman, BENHS member, leader of the society's endangered heathland flies project; Alan Stubbs, setting-up Secretary, then developing operational matters, ex-Nature Conservancy Council Entomologist and author; and Margaret Palmer, Plantlife Trustee and ex-Head of Species at JNCC.

The third conference in autumn 2001 formed a launch of the new Trust to the entomological and conservation community and focused on the issues and tasks that the new organisation would need to tackle (Cheesman 2004).

Although the ultimate formation of the new organisation was largely independent of JCCBI, the committee had provided the forum for communication and consensus.

4.3 Early Days 2002–2006 – Make or Break

In February 2002 Matt Shardlow was appointed as the first Conservation Director and an office was established in Peterborough, a reasonably central city with an existing conservationist workforce due to the presence of the headquarters of English Nature and the JNCC, and with the RSPB and Wildlife Trust HQs not too far away either.

The main conservation organisations, including the statutory agencies, issued a letter welcoming the formation of the Trust and a Memorandum of Understanding was agreed with Butterfly Conservation to ensure that the different roles of the two charities were clear (Stubbs 2002).

The organisation was rechristened as Buglife – The Invertebrate Conservation Trust and registered as a charity in May 2002. The new name was easier for public and media consumption; avoided the need for an awkward acronym; and fitted with the existing conservation charity names, Plantlife, Froglife and Birdlife. The use of the word bug was not universally appreciated by entomologists and other specialists, but retention of the longer name made the charity's full remit clear.

Before the office opened an application to the Department of the Environment, Food and Rural Affairs (Defra) (a new Government department, effectively a combination of the DoE and MAFF of the early 1990s) had been made for funding for a project to compile invertebrate habitat management knowledge relating to habitats on the Government's Biodiversity Action Plan list of priority habitats. The days of full funding of projects by Government had already passed. With only 50% funding and no time to try to raise matching funds the project was expensive and took a significant chunk out of the set-up funds. Buglife brought together leading specialists to distill knowledge. The report 'Managing Priority Habitats for Invertebrates' produced in May 2004 and updated with additional chapters in 2005 (Alexander et al. 2005) was widely distributed and even referred to by the minister in the House of Commons. Buglife had established some credibility.

One early action was to join Wildlife and Countryside Link, a forum in which wildlife and countryside Non-Governmental Organisations (NGOs) work together on government policy issues. Taking part in the working groups of this body, and later also of Scottish Environment Link, has enabled Buglife to stay abreast of policy developments, influence other NGOs and ensure that an invertebrate perspective is provided to Government on issues as diverse as biofuels, implementing the EU Water Framework Directive, agri-environment schemes, marine planning and whale conservation (save the Narwhal, save the Narwhal louse!).

A 5-year strategy was drawn-up and a clear purpose agreed, the charity would aim "To stop the extinction of invertebrate species and to achieve sustainable populations of invertebrates".

The critical period would be the first 3 years. Buglife had to convert the initial capital into revenue. If Buglife failed to become financially sustainable, it would be a very long time before anyone dared try again. Effort was put into recruiting individual members, not only did their subscription provide a buffer fund, it gave Buglife a constituency, people to represent, provided a source of assistance and an audience receptive to invertebrate conservation messages. Although membership, additional legacies, and donations were invaluable in providing the fluid money over this period, the biggest external source of funding was from charitable trusts. In particular, a generous grant from the Esmée Fairbairn Foundation enabled the recruitment of a Development Manager and an Administrator.

Although Government nature conservation agencies were very engaged and supportive during the 'Unity of Purpose' process, they were disappointingly slow to provide significant financial assistance to the new organisation. Not until 2007 did the first substantial support arrive from a nature conservation agency when

Scottish Natural Heritage funded the setting up of a post and office in Scotland. In England small grants were provided by the Environment Agency and English Nature, but significant funding was not forthcoming from English Nature or Natural England, its successor, until 2009. Again, this funding was provided on a partnership basis so needed matching funding from elsewhere. Buglife was able to grow over the first few years by setting up projects and securing funding for them. Constant attention was needed to ensure that the projects delivered Buglife's aim and did not take so much from the unrestricted funds that the administration and leadership of the charity froze.

The range of issues impacting on invertebrates was great and from the start Buglife faced them head on. A big issue identified for Buglife to tackle was the destruction of 'brownfield' habitats (a drab, uninteresting term compared with the exciting, but often largely wildlife sterile, 'greenfield'). While some brownfields are indeed of no interest to wildlife, such as hard standing, the definition was very broad, including also a range of important wildlife habitats such as those associated with quarries and disturbed ground. The mosaics of open ground, flower rich grassland, shrubs and wet features produced by industrial activities had become important refuges for many threatened invertebrate species. There were as many Red Data Book listed species on brownfield habitats as there were in ancient woodland (Gibson 1998). Unlike ancient woodland, brownfields were rapidly being redeveloped with little thought for their biodiversity importance. Indeed it was Government policy to maximise housing development on brownfield habitats. The types of sites that this would draw Buglife into defending can be challenging to traditional conservationists. Most brownfields are a long way from the natural, untouched paradise that forms a significant part of our concept of biodiversity (Shardlow 2006a). Buglife would be led by the preferences of the endangered species, not by human aesthetics.

The Thames Gateway, on the east side of London had a great deal of deserted land, including old quarries and waste sites. During the 1990s and 2000s disturbed ground in this area was found to be a biodiversity hot-spot containing many endangered and threatened species (Harvey 2000).

Canvey Wick in south Essex was an important brownfield site on the north coast of the River Thames. Once the area was part of a dynamic estuary, but the whole flood plain has long since been isolated behind large sea walls. Canvey Wick itself was saved from the vicissitudes of intensive modern agriculture as it was first covered with sandy and shingly dredgings from the Thames and then in the 1970s developed as an oil refinery that was never used. Hence the land became a refuge for species displaced from upper saltmarsh and low nutrient floodplain grassland (Shardlow 2008a). In 2002 the site, including the 32 Red Data Book listed invertebrates that lived there, was threatened by a business park development. Buglife's concerns went public in May 2003 with a full page article about 'England's rainforest' on page three of the Guardian newspaper. Within weeks the planning application was withdrawn and further surveys were undertaken. In February 2005 the majority of the site was protected by being designated as a Site of Special Scientific Interest (SSSI). There have been further set-backs since, including the building of a dual

Fig. 4.1 The public launch for Buglife, April 2004: from left to right, Germaine Greer, Nick Baker, Alan Stubbs, Matt Shardlow (Photo: Sophie Atkins)

carriage way cutting off the corner of the site. But Buglife is hopeful that Canvey Wick will soon be secured as a nature reserve for endangered invertebrates.

In July 2003 a Bill was put forward in the UK Parliament with the intention of eradicating Common Ragwort (*Senecio jacobaea*) because of its toxicity to horses. Indeed the British Horse Society promoted an extraordinary figure of 6,500 horse deaths per year, which was based on flawed statistics (the Government only recognised about 15 cases a year and seemingly Ireland and continental countries do not have any problem!). At least 31 British invertebrate species are utterly dependent on ragwort leaves, roots, stems and flowers and many more pollinators are partly dependent on its nectar and pollen. Buglife raised the alarm amongst conservation bodies and together the situation was largely defused. The outcome was a comparatively balanced set of guidelines, such that ragwort only needed control where it was a real threat to livestock.

Buglife was approached by Bridget Peacock of the Natural History Museum in 2003 to help establish a new partnership to coordinate monitoring and conservation work on riverflies (mayflies, caddisflies and stoneflies). Matt Shardlow chaired the first few meetings and helped to formalised the body into the Riverfly Partnership.

In April 2004 Buglife appointed its first President Nick Baker and Vice Presidents Germaine Greer and Professor Edward O Wilson at a well attended public launch for Buglife at the Wildfowl and Wetlands Centre, Barnes, London (Fig. 4.1).

Buglife initiated its first concerted activity in Scotland in 2004. Auchennines Moss in South West Scotland was threatened by the extension of a local authority waste-tip. The site was the only Scottish location for the Bog bush-cricket (*Metrioptera brachyptera*) and the tiny Sorrel Pygmy moth (*Enteucha acetosae*). Buglife engaged with local people already concerned about the potential environmental destruction and organised a site protest taking 'Save Our Bog' banners, this got the issue on national radio and Scottish TV news (Fig. 4.2). In the planning papers the site was described as a degraded wet heath; it did not look like a degraded wet heath. Buglife called in Richard Lindsay, an international bog expert based at the University of East London. He determined that the site was indeed a raised bog, a Biodiversity Action Plan (BAP) listed Priority Habitat, also protected by the European Habitats Directive (Lindsay 2004a). Britain holds the majority of European raised bogs, nearly all are damaged to some extent, but the big ones in Scotland did not support the above species. Buglife asked SNH to make the site an SSSI, but without success (Lindsay 2004b). Buglife took the case to the European Commission but they would only take interest if the mis-classification was shown to be part of a systematic problem. Chris Ballance, a Green Party MSP, tabled a motion in the Scottish Parliament asking for Aucheninnes Moss to be saved from destruction. By July 2004, with campaign support from Buglife, 31% of MSPs signed-up to the motion. The importance of invertebrate conservation was underlined and the site became politically sensitive. Eventually, in 2009, the local council dropped its waste disposal plans and the moss was saved.

The Aucheninnes case also highlighted the importance of common names in getting the support of the public and politicians. In the Environmental Impact Assessment that accompanied the landfill proposal both the Bog bush-cricket (*Metrioptera brachyptera*) and *Enteucha acetosae* were mentioned as site specialties. While the public was vociferous about the Bog bush-cricket, there was silence about *Enteucha acetosae*. Buglife put out a press release that also gave the English name of the moth, suddenly there were letters in the local paper and being sent to politicians asking why they had not been told that the Sorrel Pygmy moth was also threatened with national extinction. The scientific name was meaningless to the local populace, but the Sorrel pygmy moth had 'character'.

In 2004 the innocuous sounding Clean Neighbourhoods Bill, surely concerned with litter and the like, went before Parliament. Buried deep in the Bill was a clause that gave local authority officers the power to declare any population of insects to be a 'statutory nuisance' and order them to be eliminated. Was this to be wasps and mosquitoes, or even harmless midges and other flies? Some members of the public would regard any type of insect as a nuisance. How could farmers ensure that flies along public footpaths, or straying off their land, would not cause someone a nuisance? Buglife quickly pointed out the potential cost implications to the National Farmers Union and highlighted to the RSPB the problems that birds would face if fly populations were routinely deterred or destroyed. The support of these two organisations enabled Buglife to secure a meeting with a senior civil servant. Buglife convinced the official that the proposed legislation was disproportionate to the problem and if implemented would inevitably result in environmental damage. In March 2005, at the eleventh hour, the wording was changed and the Clean Neighbourhoods Act emerged with a clause ensuring that insects in the countryside were safe from being declared a statutory nuisance.

Fig. 4.2 The site protest on Auchennines Moss, 2004 (Photo: Paul Raeburn)

Getting public endorsement for invertebrate conservation was going to be essential to convincing politicians that conserving invertebrates would bring them support rather than derision. Buglife established a website purveying lots of positive information about invertebrates and encouraging people to take part in bug related activities. The charity also produced the first four poster-leaflets extolling the virtues of particular taxonomic groups of invertebrate in November 2004. By 2011 there were ten leaflets in the widely acclaimed series, including Riverflies, Beetles, Flies, Spiders and Freshwater Crustaceans; they are regularly found gracing the walls of schools, reserve centres and wildlife offices across the UK. It is difficult to get messages about invertebrate conservation across to the populace using just leaflets and a website. Early on, Buglife showed an aptitude for working with the media. Buglife's work was quirky and interesting, but also serious and challenging; it was a successful mix and newspaper articles, radio interviews started to flow. One of the highlights was in June 2006 when a beetle that Buglife was working on, the Scarlet Malachite beetle (*Malachius aeneus*) appeared on front cover of Independent newspaper (Fig. 4.3), and the paper donated 10p to Buglife from every copy sold, £19.5 K in total.

A few years before the establishment of Buglife concerns about the effects of organophosphate sheep-dips on the farmers using them had resulted in many of them being withdrawn from use. Cypermethrin became the preferred alternative. While Cypermethrin had lower vertebrate toxicity it had orders of magnitude higher toxicity to invertebrates (Shardlow 2006b). Pollution events involving Cypermethrin

Saturday
Edition

THE INDEPENDENT

20P FROM EVERY COPY HELPS TO SAVE BRITISH WILDLIFE

This scarlet malachite beetle is in imminent danger of extinction, a fate which has claimed more than 200 species of insects in Britain in the past 30 years. Native plant life is similarly under threat. By buying today's newspaper, you can aid two charities dedicated to protecting the country's flora and fauna

SEE PAGE 2

Win business class flights to New York

James Lawton: The case against Beckham

The 50 Best cameras and camcorders

Fig. 4.3 The front page of 'The Independent' (24 June 2006), with publicity for the Scarlet Malachite beetle, *Malachius aeneus*

sheep-dip and watercourses did not result in the emotive sight of flotillas of dead fish, but did eradicate most of the invertebrates. Data from Environment Agency monitoring started to detect a worrying number of pollution events. Buglife assembled the available data on such pollution incidents and estimated that about 1,000 miles of watercourse were being affected every year, killing at least 1.5 billion invertebrates. In Summer 2005 Buglife asked for the use of Cypermethrin to be banned. In February 2006 the sale of the chemical as a sheep-dip was suspended and an Environment Agency chaired steering group established to investigate options. Heated meetings followed, with the farming sector (including the Soil Association), agrochemical companies and Scottish government bodies lobbying hard for the chemical to be restored to the market; they seemed to have the ear of the Veterinary Medicines Directorate at Defra. Buglife, the Salmon and Trout Association and the Angling Conservation Trust held firm. Eventually an Environment Agency study showed that even weeks after being dipped it would be possible for a single sheep walking through 9 cm of water to release enough Cypermethrin to cause a measurable pollution incident in a river. This proved the scale and unmanageability of the problem and Cypermethrin sheep-dip was banned in March 2010. In terms of the numbers of insects saved and area of habitat improved, this is probably one of the biggest achievements in Buglife's history, but it almost certainly didn't register on the radar of most entomologists.

An early delivery partnership that Buglife joined was 'Action for Invertebrates', with Natural England, the RSPB and Butterfly Conservation. The partnership had been established to study and conserve some of the BAP species for which there was at the time no obvious Lead Partner. An example of such a species was the Scarce Yellow Splinter (*Lipsothrix nigristigma*), one of four *Lipsothrix* craneflies that live in woody debris in streams. Not only had their ecology been neglected, the habitat itself was not valued; indeed the convention was to remove woody debris as it was viewed as a flood risk, bad for fisheries and generally awkward and untidy. 'Action for Invertebrates' substantially improved knowledge of life histories, ecologies and habitat management strategy (Godfrey and Middlebrook 2007). Hewitt and Parker (2005) revealed that species distribution patterns were partly related to differences in woodland management history. The Staffordshire Wildlife Trust produced a focused habitat management booklet (Mott 2006) and undertook a study on another key coarse woody debris species – the Logjammer hoverfly *Chalcosyrphus eunotus* (Jukes 2009). It is now realised that, rather than being an obstacle to fishes (and fishing lines!), large woody debris benefits fish by creating a more diverse river structure and more invertebrate fish food. The Wild Trout Trust, the Environment Agency and others now actively discourage the removal of woody debris from water courses. The 'Action for Invertebrates' partnership came to an end when the RSPB decided to focus on other priorities.

The Natural Environment and Rural Communities (NERC) Act (2006) introduced a biodiversity duty; public bodies in England and Wales had to have regard for species and habitats listed under the Act. In addition the Secretary of State and Welsh Assembly Governments were given a duty to further the conservation of said species and habitats. Scotland already had a duty to further the conservation of species listed under the Nature Conservation (Scotland) Act (2004). The NERC Act also combined English Nature with the Countryside Commission and Rural Payments Service to create a new agency – Natural England.

By 2006 Buglife had shown that its model was financially workable, the charity could be a determined advocate for invertebrates and raise sufficient financial resources to grow and develop. There were now seven staff, Matt Shardlow had been promoted to Chief Executive, other staff included Jamie Roberts the Conservation Projects Manager and Kathy Wormald the Development Manager. Both were to go on to greater things, respectively as Director of St Helena National Trust and Chief Executive of Froglife. The Board of Trustees was also benefitting from new blood having appointed Sue Walton, John Feltwell and Helen Boothman. Alan Stubbs had taken on the Chairman's role in 2004, the same year in which he received the Marsh Award for Insect Conservation (Anon 2004), and in 2006 Germaine Greer, perhaps the world's most famous feminist, was appointed as President. She had proven herself to be a dedicated supporter of the charity's work, speaking out on behalf of bugs and even nominating Buglife as the charity to benefit from a £20,000 donation as a result of her appearance in the reality TV show 'Celebrity Big Brother'. In the same year Margaret Palmer, back on the Board after a break due to illness, was awarded an MBE for her contribution to nature conservation.

4.4 2007–2008 Consolidation and a Bump

In February 2007 Buglife employed Craig Macadam as its first Scottish Conservation Officer and established an office in Stirling. This made the town unique, not just the only place in the world with more than one invertebrate conservation charity office; it now had three, the Butterfly Conservation and Buglife Scottish offices and the headquarters of the Bumblebee Conservation Trust.

2007 also marked a significant point in the Biodiversity Action Plan process. For 3 years Buglife had worked hard under the UK BAP Steering Group, with assistance of member organisations and individual experts and in partnership with JNCC, Butterfly Conservation and the JCCBI, to develop new criteria and a new list of BAP priority species (Roberts 2005). The process had almost been derailed in 2006. English Nature (EN), SNH and CCW entomologists had not engaged with developing the criteria (although the criteria were signed off by their senior officers), gathering hundreds of application forms – one for each species, quality assuring the forms or judging the species carefully against the criteria (and neither had the EN or SNH marine specialists assisted with developing the list of marine species, although CCW's did). Suddenly the entomologists from the agencies interceded, removing from the list a great many of the species that the partnership had judged to have met the criteria. A further series of meetings were needed, this time with the Government agency entomologists involved to rescue the situation. In June 2007 the new UK BAP Priority list was produced; it included 431 invertebrate species. These species formed the basis of the lists of species protected in England and Wales by the NERC Act.

Another very significant change was the inclusion of 'Open Mosaic Habitats on Previously Developed Land' on the BAP Priority habitat list. Buglife's awareness-raising on the importance of brownfield sites for endangered species had helped to change perceptions of the value of the habitat.

In retrospect the production of the revised UK BAP list looks like a last 'great hurrah' of the UK BAP process and cautious optimism at the time (Shardlow 2007; Environmental Audit Committee 2008) is now looking misplaced. Tensions between countries, now with far greater devolved responsibilities for nature conservation, combined with a lack of enthusiasm or vision from the Government's conservation agencies, were making the process extremely slow. To date Government has taken little action to address the new list of species and habitats, and what modest action it has taken is of poor quality (Macadam and Shardlow 2009), there are no longer action plans or targets for the species, and the Lead Partner system, whereby organisations were appointed to overview the conservation work for the species and to ensure that there was monitoring, has been scrapped at a UK level and not yet been replaced at a country level.

A significant project in this period examined another neglected invertebrate habitat – coastal soft rock cliffs. Surveys of key areas were undertaken – generating 10,400 new invertebrate records, additional data on the distribution of key species dependant on the habitat was gathered, and advice provided on the management of the most important soft rock cliffs (SRC reports and paper 2006–2008). This habitat is likely to be affected by changing rates of erosion due to sea level rise, but the project was unable to quantify the effects of this issue.

In March 2008 Buglife produced 'Bringing Aggregates Sites to Life – best practice habitat management guide' (Whitehouse 2008). This gave advice to the minerals industry on how to maximise biodiversity benefits from extraction activities and site after-use. While there is good positive action that can be taken, in many cases what is best for biodiversity is less of the top-soiling and tree planting which have typically dominated post-extraction wildlife restoration schemes. For invertebrates the bare areas and ruderal vegetation created by the earth-working are far more valuable (Whitehouse 2009).

A bumblebee project in Essex and East London encouraged people to look for bumblebees and trained 500 people how to identify them. Buglife helped put together OPAL (Open Air Laboratories) water survey packs that were sent to 50,000 people to encourage them to investigate pond invertebrates. These are two of many initiatives to encourage people to engage with invertebrates more positively, other initiatives have included a simple spider survey, a 'Stop Swatting Wasps' campaign, a National Worm Week and a public survey of oil beetles (Meloidae). The latter initiatives were ably supported by Dale Harrison, Buglife's first Outreach Officer.

Between 2007 and 2009 the Government put forward a new solution to environmental damage resulting from growing housing needs. Ecotowns were promoted as being sustainable, environmentally benign new habitations. Buglife was keen that the concept would encompass more than just low carbon; it should also mean low biodiversity damage and high biodiversity benefits. Indeed Buglife took a leading role in Wildlife and Countryside Link's Ecotown engagement, representing the forum and contributing to the drafting of the Town and Country Planning Association's guidance worksheets. Not all the proposed Ecotown sites obviously met the guidelines. One proposed Ecotown to raise concerns was next to Weston Fen SSSI, North East of Oxford. At face value building on adjacent dry ground would have no direct impact on the valley stream feeding the wetland. A Buglife site visit revealed that the stream was not the sole story. On the flanks there was groundwater-fed seepage fen, including a major one originating high up the slope above the stream; indeed there was even a spring-fed stream flowing down the slope. If the land overlying the aquifer was covered in concrete, the groundwater level would fall and both seepages and spring could dry out, especially during the summer. The SSSI designation was of little assistance as it failed to recognise the hydrological functioning, or the habitat's value to invertebrate biodiversity. In 2011 the new Government announced that the developments could be built to normal building requirements. While these may not now be Ecotowns it remains to be seen if Local Authorities will still set higher than usual environmental standards or indeed if without the promise of Government support the developers will lose interest completely.

In March 2008 Buglife completed a project called ‘All of a Buzz in the Thames Gateway’. Conceived with Natural England the project mapped-out 576 brownfield sites in London and the Thames Gateway. Using a standard assessment form (Buglife 2008) expert brownfield entomologists assessed the likely biodiversity importance of the sites. 55% of the area was shown to have high biodiversity potential, but at the then rates of development it would all be built on in 20 years (All of a Buzz in the Thames Gateway reports and papers 2006–2008).

The biggest bump in Buglife’s development came in Spring 2008 when ‘All of a Buzz….’ and a couple of other projects came to an end in close succession. Many follow-on and new project proposals had been submitted for funding in the preceding months, but all had been turned down. Three project officers left at the end of their contracts and momentum had to be rebuilt.

There were, however, a number of other much more positive indicators. In 2008 the number of individual Buglife members went over 1,000 for the first time and Buglife produced its second 5 year strategy ‘Growing Success’ reaffirming the charity’s original aim and now setting out 29 Key Result Areas with targets to meet.

4.5 West Thurrock Marshes – The Battle Royal

2008 was also the year that Buglife first took legal action to protect wildlife. The land in question was West Thurrock Marshes in Essex, close to the M25 London orbital motorway, and part of the Thames Gateway area. The substrate on the site was pulverised fuel ash from a demolished adjacent power station. This material mimicked the dynamic coastal sands that would have been present when it was part of a functioning estuarine floodplain, and it supported an exceptional invertebrate fauna. Early in 2006 a planning application had been submitted for a huge Royal Mail warehouse and lorry park on West Thurrock Marshes.

Buglife highlighted that, with three BAP Priority Species and an assemblage of 36 rare animals, for its area the site had perhaps the greatest concentration of rare and endangered species in Britain (for more on the ecological significance of the site see Shardlow 2008b). English Nature refused to make it an SSSI, but decided that development of half the site would be acceptable if the developer, Goodman (then Rosemound), guaranteed to safeguard and manage the remainder, and if a small SSSI on a patch of adjacent fly ash land, on which the wetland bird population had declined, was brought back into favourable condition. This would be achieved by digging a pond-liner into the ground and reflooding the SSSI; good for the water-associated birds for which it had been designated, but further damaging populations of open ground and flower associated BAP invertebrate species. Buglife, in partnership with the local Council and Essex Wildlife Trust, pushed hard for a less damaging scheme to be developed, but in November 2006 the Thurrock Development Corporation approved the plans.

Buglife immediately took action, launching an online petition which more than 2,500 people signed. A motion in the House of Commons was tabled, calling for the protection of the site, which received cross-party support. In January 2007 Buglife met with Prime Minister Tony Blair and the Biodiversity Minister to press for the site to be protected. As was said at the time, "if you can't protect the second best invertebrate wildlife site in the UK, what's safe?"

With the politicians unwilling to review the decision, Buglife decided that it must secure a Judicial Review through the courts, a costly and time-consuming process, but to surrender would have been to concede that invertebrate conservation counted for little or nothing in the planning process. The challenge was multi-facetted, including that public authorities, such as the Thurrock Development Corporation, had a duty to have regard to biodiversity conservation (NERC Act 2006). It also appeared as if the Development Corporation had made no serious effort to weigh the loss of biodiversity against the benefits of the development, or to look to see if an alternative site could be found where development would result in less biodiversity damage – both actions are required if the Government's formal planning guidance is followed. The Judge ruled that the Development Corporation was guided by the primary legislation to always 'develop' so, in effect, did not have to apply planning guidance and that its develop 'objective' also over-ruled the biodiversity 'duty'. This and other key aspects in the judgment appeared to be flawed, so an appeal was made. This time three judges reached the conclusion that while Buglife was right to expect the additional protection for biodiversity, if that biodiversity was to be damaged, in this case the Development Corporation was able to interpret one sentence in a Natural England letter that stated that "over the longer term, if the future of retained area and compensatory habitats are secure there is the possibility of a long term nature conservation gain for the area" as meaning that there would be no damage to biodiversity and hence the biodiversity tests, duty and guidance did not apply. This conclusion was reached because the court applied a test of Wednesbury reasonableness to the Development Corporation's decision, in other words, because of the line in Natural England's letter it was not unreasonable for the Development Corporation to believe that there would be no biodiversity damage – despite the clear statements in the Environmental Impact Assessment documents that indicated that there would be very significant damage to rare invertebrates. Buglife argued that the Environmental Impact Assessment process originated in EU legislation and that the Wednesbury Test was a test only applicable to domestic law, the correct test for European law being one that assesses the correctness, not just the rationality, of the decision - i.e. was the specific decision that the proposal would not damage biodiversity correct. This important question was never addressed as an application to appeal on the basis of this point was turned down by the highest court, the House of Lords.

The proposed development was to have been a distribution centre for Royal Mail, the national postal service. Fortuitously, Royal Mail produced a set of stamps depicting endangered insect species, an unfortunate step in view of their plans at Thurrock. Buglife got much publicity by giving the media its alternative stamp designs showing instead rare and BAP species threatened by the Royal Mail's activities, with the postal category '1st' changed to 'last' (Fig. 4.4). Buglife members wrote to the Royal Mail chief executive expressing concern. Not long afterwards Royal Mail pulled out of involvement in West Thurrock Marshes. Promptly the Royal Mail distribution

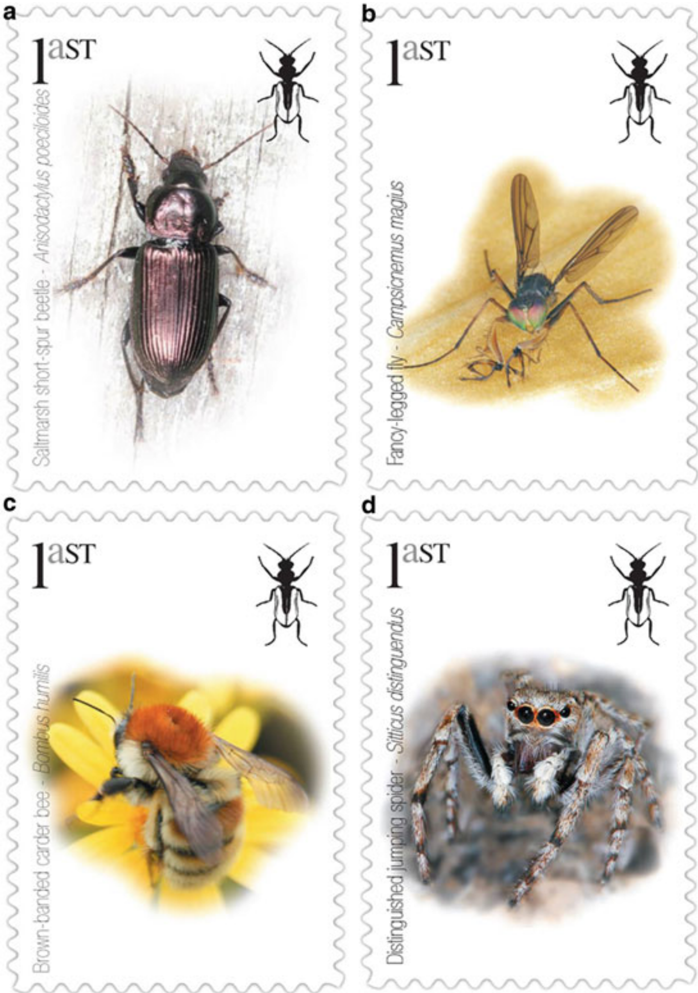

Fig. 4.4 The 'alternative stamp designs' from Buglife, produced as part of the campaign for West Thurrock Marshes: (**a**) the Saltmarsh Short-spur beetle, *Anisodactylus poeciloides*; (**b**) the Fancy-legged fly, *Campsicnemus magius*; (**c**) the Brown-banded Carder bee, *Bombus humilis*; (**d**) the Distinguished jumping spider, *Sittius distinguendus*

centre was built on a site also owned by Goodman of no biodiversity significance on the other side of the road from West Thurrock Marshes, rubbing salt into the wound caused by the fact that the 'no alternative sites' test had not been applied.

There were many positive outcomes from this legal action. It was the first time that biodiversity protection had been tested in UK courts and it clarified that relevant legislation and biodiversity related planning policy guidance were important considerations. Indeed at least one other invertebrate rich site, Buckman's Quarry, also in South Essex, has been protected on the exact basis of the principles that the case established. The legal process emphasised the importance of Natural England's advice in decision making. The case was high profile and highlighted the frailty of the Biodiversity Duty and weaknesses of the court system in addressing environmental damage.

Buglife was awarded the 2009 Observer Ethical Award for conservation in recognition of the ground breaking campaign. West Thurrock Marshes had become a national symbol of society's failure to protect biodiversity; hopefully this awareness will ultimately contribute to a solution to the problem.

The fate of West Thurrock Marshes has not yet been sealed. As of September 2011 there has been no development of the site, so Buglife's interventions have given the endangered species at least 5 years to proliferate and disperse. The planned development will destroy over half of the site, including 70% of the flower-rich areas upon which so many of the insects depend on, a tragedy for biodiversity conservation. However, Buglife has not given up hope that the wildlife of West Thurrock Marshes will be saved.

4.6 2009–2011 – To the Ends of the Earth and the Fall of the Bees

Buglife is not constrained to activities just in the British Isles: surveyors have been sent to sites in France and the Netherlands; have undertaken a thorough invertebrate survey of the island of South Georgia in the Antarctic (Key and Key 2009; Convey et al. 2010); and have been actively developing invertebrate conservation projects with partners in Sri Lanka, Kenya and St Helena. Alongside Butterfly Conservation Europe, Buglife also represents invertebrates on the European Habitats Forum, the main Europe wide nature conservation NGO partnership.

There has been a constant stream of threats to invertebrate habitats. Dungeness is the largest coastal shingle foreland in Europe, with a great many associated rare spiders, ants, bees, beetles, moths and the Medicinal leech. Buglife helped to protect Dungeness from a new nuclear power station, but it is still threatened by a huge expansion planned for Lydd airfield, to change this local airfield into an international airport (London Ashford). If approved, not only will this damage shingle and ditch habitats, the low nutrient habitat is particularly vulnerable to the localised nitrate pollution that occurs around airports due to the burning of fossil fuels.

Other instances of Buglife involvement with saving and protecting key invertebrate sites have included giving strong backing to the notification of Red Lodge Heath in West Suffolk and Highgate Common in Staffordshire as SSSIs, and supporting Gus Jones and the Badenoch and Strathspey Conservation Group (BSGC) in fending off large building plans in the Spey Valley and Cairngorms National Park. This area is a key biodiversity hot-spot and the development-friendly local plan produced by the Cairngorms National Park Authority is currently being legally challenged by the BSGC and others on the basis that it fails to further the conservation of biodiversity.

In January 2009 Buglife published 'A strategy for Scottish invertebrate conservation' (Macadam and Rotheray 2009). The strategy represented the views of over 100 leading conservation experts, and set out a series of tasks, harnessing the expertise and enthusiasm of hundreds of volunteers to ensure that threatened habitats, sites and species are identified and conserved. Launching the strategy, Michael Russell, the Scottish Minister for Environment said:

> It must be stressed that many invertebrate species are critical to the Scottish economy. They clean rivers, pollinate crops and income from fisheries depends on strong invertebrate populations.
>
> Langoustine (Norway lobster or Scampi), a marine invertebrate, contributed £89.3 million to the Scottish economy in 2007, more than the combined value of cod, haddock and monkfish catches, clearly demonstrating that this is a species that must be treated with the utmost importance.
>
> I hope that today's launch will encourage many Scots to take an interest in what is a fascinating range of species and ensure that we all work together to ensure they have a future in Scotland.

The tiny remaining fragments of Aspen (*Populus tremula*) woodland in Scotland are of great significance to endangered invertebrates including the deadwood feeding Aspen hoverfly (*Hammerschmidtia ferruginea*) and the young-growth associated Dark-bordered Beauty moth (*Epione vespertaria*). Butterfly Conservation and Buglife compiled a list of 17 aspen-dependent moth species (Prescott and Stubbs 2009). There are also several flies, beetles, lichen and fungi species only on these aspen trees in Britain. The proposed re-introduction of the beaver into the Scottish Highlands raised concerns because of the animal's predilection for aspen. Buglife was alone in publicly voicing concerns about the reintroduction proposal, suggesting that new areas of aspen woodland should be established as a matter of urgency to avoid the risk of a loss of continuity of deadwood habitat, and highlighting that ten aspen-dependent insects had already gone extinct in Britain and without care more would follow (Macadam 2008). In May 2009 beavers were released into the wild, but in western Scotland, a considerable distance from the most significant aspen forests in the Spey Valley and Highlands. While there is no immediate conflict, the beaver may successfully spread and if it does then the risk to deadwood supply highlighted by Buglife has not been addressed.

Having been involved in defining the criteria for identifying nationally important marine conservation areas (Connor et al. 2002), Buglife again applied its influence during the passage through Parliament of the Marine Act 2009. The original version did not make it clear that marine invertebrates would be included in its protective measures. After a debate in the House of Lords the Bill was amended to make it clear that the term animals included eggs, larvae and pupae – the biological implication was clear.

In the mid 2000s there was increasing concern in society about the loss of bees. The driver for this was not the alarming declines in populations of bumblebees, moths, hoverflies and other wild pollinators (Stubbs 2010a, b; Fox et al. 2006; Stuart Ball pers. comm.), but the decline in the domesticated honeybee (*Apis mellifera*). While in the public's mind pollination and the honeybee are closely entwined, in fact in Britain the honeybee is only rarely found in the wild, as escaped swarms that have set up nest. There is little evidence that honeybees can persist, or have ever flourished in the British countryside without human assistance. In addition only about 10% of pollination visits and probably a lower percentage of pollination events are actually carried out by honeybees; around 90% of pollination happens because of the many species of wild pollinators. The causes of the honeybee decline were unclear, with several potentially different factors at work, including: sudden inexplicable colony loss, as witnessed through Colony Collapse Disorder in the USA; increases in the parasitic *Varroa* mite; loss of wildflowers; loss of beekeepers; reduced overwinter survival of colonies; viruses and diseases; and pesticides. A number of these issues are honeybee-specific so are unlikely to indicate environmental damage. However, it is clear that the loss of wildflowers in the countryside is a big issue for bumblebees, and hence was likely to be a significant factor for honeybees as well. Another issue, the impacts of new types of pesticides was unclear. Could it be that systemic insecticides, primarily Neonicotinoids and Fipronil, applied to a seed, but then active throughout the life of the plant including persisting in the resulting nectar and pollen, were impacting on domestic and wild pollinators?

Despite there being considerable controversy about the use of Neonicotinoids, whenever questioned the Government's response was that the evidence led them to believe that the Neonicotinoids were not a problem. But what was this evidence? Buglife undertook a thorough review of all the available literature on Neonicotinoid pesticides to examine the evidence relating to their risk or safety to the environment. The resulting report 'The impact of neonicotinoid insecticides on bumblebees, Honey bees and other non-target invertebrates' by Vicky Kindemba (2009), Buglife's Freshwater and Farming Officer, was a watershed. For the first time all the available evidence was presented together. It was clear that the majority of the laboratory studies looking at honeybee and bumblebee health showed that at levels of the pesticide that would be encountered in the field there were significant reductions in foraging activity and fecundity. These results were not replicated in field studies, but as almost all the field studies looked at a period of days, or very rarely a couple of weeks; the long term ecological impacts of Neonicotinoids had not been established. Hence Buglife recommended that the use of the pesticides should be suspended until there was clear evidence that they were not causing environmental harm; Buglife was supported in this by a number of other charities including Plantlife and the Soil Association. Buglife presented the new report to the Prime Minister's environmental advisor at a meeting about bee conservation at Number 10 Downing Street in September 2009. Government was slow to respond (eventually doing so in July 2010), but Buglife kept up the pressure. In February 2011 Martin Caton MP took up the issue and secured a full debate on the subject in the House of Commons. Despite concern from MPs from all the main political parties, the Minister Jim Paice stuck to the UK Government line that there was no field evidence of damage to honeybee populations so the chemical was safe.

Since Buglife's original report was produced some additional science has been done, some directly as a result of the report, a meta study of published field studies found that none of them had sufficient statistical sensitivity to detect the reductions in activity and fecundity predicted from the laboratory studies. Also laboratory studies using honeybees showed that there is a link between exposure to Neonicotinoids and susceptibility to the disease *Nosema*. In addition a 2008 Defra report has come to light that states that, in relation to testing the safety of pesticides, honeybees are not a suitable surrogate for other pollinating insects and further data would need to be gathered to assess if systemic Neonicotinoids were safe to wild pollinators. Despite bans on Neonicotinoids in France, Italy and Slovenia, the UK has yet to suspend or ban them, maintaining that there is no new evidence of likely environmental damage. However, it is interesting that the UK did not renew the license for the systemic pesticide Fipronil when it came to an end. Meanwhile Buglife has set up a Biodiversity and Pesticides group with a number of other environmental NGOs to focus on pesticide issues and has yet to see research that shows that wild pollinator populations are not being affected by the Neonicotinoids in their nectar and pollen. Buglife maintains the position that a suspension is required until their environmental safety has been proven.

Work has been progressing under the auspices of 'A strategy for Scottish invertebrate conservation'. Over the past 2 years Buglife has been helping to make the study of invertebrates more accessible. A range of workshops have been run in Scotland, including, an introduction to invertebrates, springtails, pseudoscorpions, harvestmen, beetles, aquatic invertebrates and deadwood management for invertebrates. Held in partnership with invertebrate specialists they have proved extremely popular. There are now waiting lists for future workshops and other organisations have started holding similar workshops in Scotland. In addition Buglife has begun the arduous process of creating checklists of Scottish invertebrates, the first time that an attempt has been made to discern Scotland's subset of the British fauna. Buglife has published 47 checklists to date, from freshwater flatworms to scorpionflies and even including the parasitoid wasps. Each species is accompanied by the conservation status, and other additional information, forming a 'knowledge dossier' to help people study and conserve the species. Buglife is also developing an invertebrate conservation education pack for primary school children in Scotland.

In the last 2 years Buglife's early work producing habitat management guidance has continued with a series of sheets to help farmers, landowners and conservation advisors to target their work and get agri-environment support for saving particular species such as the Large Garden bumblebee (*Bombus ruderatus*) and the Necklace ground beetle (*Carabus monilis*), and important habitats such as grazing marsh ditches. Buglife has produced new reedbed management guidance with the RSPB and others as part of their 'Bringing Reedbeds to Life' project. In Scotland Buglife has produced management guidance for landowners to help them to manage their land in a way that will benefit invertebrates. Currently guidance is available for cereal field margins, lowland raised bogs, blanket bogs, coastal vegetated shingle, ponds, deadwood and school grounds.

In 2011 Buglife completed another huge project – 'The ecological status of ditch systems'. Buglife surveyed over 500 ditches in the most important coastal grazing marsh areas of Wales and England. Both plants and invertebrates were recorded and the quality of the flora and fauna was assessed using a new standardised methodology (Palmer et al. 2010). The project also gathered data on a range of environmental variables. Associated work linked ditch water quality to diatom population structure; produced a bibliography of ditch studies (Driscoll 2007); revealed the deterioration of biodiversity associated with arablisation of Norfolk grazing marsh and the subsequent near full recovery many years after grazing was reintroduced (Drake 2011); and computerised data from 6,300 ditches surveyed in 34 previous studies. The conclusion of the main study was that the quality of the wildlife in ditches in grazing marshes managed for nature conservation had generally improved over recent decades (Drake et al. 2010). The project helped to clarify the environmental variables that define invertebrate and plant assemblages, but perhaps the most significant achievement has been to set a solid baseline against which any future changes in ditch ecology can be referenced. The project also highlighted that salinity levels set ditch ecology, so rising sea levels could greatly alter the nature of these systems which would threaten several rare and vulnerable species associated with fresher ditches.

Buglife's work on brownfield projects has taken-off since the employment of Sarah Henshall as Brownfield Conservation Officer in 2009. Buglife is now assessing brownfield habitat quality throughout the UK, conducting invertebrate surveys and working with landowners to manage and create invertebrate habitats across a network of brownfield sites in South Essex, Teesside (North East England), Scunthorpe (Lincolnshire), Irk Valley (Manchester) and Falkirk (Central Scotland) (Bairner and Macadam 2011; Macadam and Bairner in press). The charity, working with other NGOs, also produced a thorough guide to planning policy and practical management of wildlife on open mosaic habitats on previously developed land 'Planning for Brownfield Biodiversity' (Buglife 2009). Buglife is also collating information on which rare and threatened invertebrates depend on the habitat and the fauna associated with the ruderal vegetation of open mosaic habitats. Buglife engages with Local Authority planners, developers and ecological consultants to try to ensure that brownfield habitats and species are properly considered in the planning process. The aim is to ensure the most important sites are protected from development and that appropriate mitigation and compensation is secured on sites that are developed, perhaps the only way of achieving this is to redefine the term 'brownfield' to exclude sites of importance to wildlife.

Sand and shingle bars and beaches along rivers are another classic bare ground containing habitat of great interest to invertebrates, but of little interest to other conservation NGOs. Buglife, working with the Environment Agency and CCW, surveyed many of the most significant Exposed Riverine Sediment deposits in England, Wales and Scotland for their Diptera fauna. The other significant group, the Coleoptera, had been previously well studied by, amongst others, Buglife trustee Jon Sadler (Eyre et al. 2001; Eyre and Luff 2002; Sadler et al. 2004; Bates et al. 2009; Henshall et al. 2011 and Henshall 2011). As well as extending knowledge of the distribution of rare species such as the Southern Silver Stiletto fly (*Cliorismia rustica*); assessing the impact on the fauna of gravel extraction; and devising a new habitat assessment method; the project also discovered three habitat specialists new to Britain, two balloon flies and a long-legged fly (ERS reports and papers 2007–2011).

'A Review of the Impact of Artificial Light on Invertebrates' (Bruce-White and Shardlow 2011) assembled all the evidence relating to all forms of light pollution and made pertinent policy and practical recommendations. The science showed that artificial lighting and shiny flat surfaces in the wrong place and at the wrong time could significantly disrupt ecosystems, and might be contributing to current declines in and extinctions of invertebrates. Artificial night lighting disrupts the natural rhythms of light that govern the feeding, breeding and migration patterns of nocturnal insects, including moths, beetles, and lacewings, as well as water fleas (*Daphnia*) thereby having a profound effect on ecosystems.

A newer problem highlighted by the report is polarised light pollution. For the whole history of the Earth, all flat shiny surfaces that reflected polarised light were ponds or rivers. Suddenly there are thousands of similar artificial surfaces such as plastic sheeting on agricultural fields, shiny tarmac, cars, and now proliferating solar panels. Dispersing aquatic insects are attracted to these surfaces and, believing them to be watery habitats, they deposit their precious eggs to perish in the sun.

The light pollution report recommended: incorporating patterns of rough or painted glass on the solar panels to break up the polarised light; switching outdoor lights off between midnight and 5am; incorporating motion-sensors to switch-off security and footpath lighting; reducing polarised light pollution by locating car parks away from water bodies and using rough tarmac surfaces; avoiding bulbs that emit ultra-violet light; minimising light pollution in sensitive locations such as conservation areas, ponds, rivers and the sea; including light pollution data in Environmental Impact Assessments; identifying and protecting wildlife-important areas that currently have low lighting levels; and designating new Dark Sky Preserves.

In this chapter we have barely touched on Buglife's direct work on species. It is essential to gather the fundamental information about the ecological needs and most pertinent threats to the fastest declining and most vulnerable species and to convert this into the appropriate action, including the correct habitat management. Without this information conservation activities are poorly directioned and inefficient. Buglife has spent considerable effort in saving our native While-clawed crayfish (*Austropotamobius pallipes*) (Holdich et al. 2009) including translocations to new safe havens and establishing the UK Crayfish website www.crayfish.org.uk (Peay et al. 2011; Whitehouse et al. 2009; Kindemba and Whitehouse 2009; Kindemba et al. 2009); captive breeding Scarlet Malachite beetles (*Malachius aeneus*); hunting through European fens looking for Rosser's sac spider (*Clubiona rosserae*) (*Clubiona rosserae* reports 2002–2010); sifting flood debris to find Crystal moss animal statoblasts (*Lophopus cystallinus*) (Hill 2006a, b; 2011); putting out twiggy traps in hollow trees with the British Arachnological Society to catch the Midas tree weaver (*Midia midas*) (Russell-Smith 2010); working with the Conchological Society to ensure that the Lesser whirlpool ram's horn snail (*Anisus vorticulus*) gets the habitat protection it requires (Shardlow 2009) and that the Roman snail (*Helix pomatia*) is given legal protection to halt the exploitation of wild populations for the restaurant trade; and even just making sure that someone is looking out for the Barred Green Colonel (*Odontomyia hydroleon*) and Desmoulin's whorl snail (*Vertigo moulinsiana*)

(Williams 2006). Buglife has worked directly on conserving over 50 species, usually with the assistance of volunteers and specialist invertebrate societies, attempting to create a future in which these endangered animals can again thrive.

The Riverfly Partnership has flourished and now has nearly 100 partner organisations, employs two staff members (Bridget Peacock is the Director) and undertakes three main functions; coordinating the Anglers Monitoring Initiative; training anglers and others about riverflies and their ecology; and coordinating work on the threatened and endangered species and habitat protection. In 2009 the Environment Agency successfully prosecuted a timber construction company for polluting the River Rhymney in Wales with Permethrin. Without the monitoring of the invertebrate fauna by local anglers, the incident would never have been detected; this is the third successful prosecution resulting from data gathered by the Riverfly Partnership. Buglife now chairs the Species and Habitat group of the partnership which recently completed a conservation project on the eight BAP listed riverfly species. New expert survey data was collected, identification postcards distributed to enable anglers to record the threatened animals in their local rivers, and management advice sheets produced.

The loss of three million hectares of wildflower rich grassland in Britain since the Second World War has been an unmitigated disaster for wild pollinators. Agri-environment schemes have to date only replaced 0.2% of the area lost. Buglife and numerous partners are now active on a new concept called ‘B-Lines’ that is being developed with support from the Co-operative supermarket, the largest farmer in the UK. The vision is for swaths of wildflower rich habitat to spread across the landscape; restoring whole fields to wildflowers and linking together remaining fragments of wildflower rich habitat. This would create a broad network of 150,000 ha of high nature value farmland along which species can move and disperse, particularly in response to climate change. A pilot project in Yorkshire is testing the application of the concept on the ground, creating new wildflower meadows and mapping the routes of the potential B-Lines.

Buglife launched the ‘Get Britain Buzzing’ campaign in May 2011. The aim of the campaign is to get more people to take action to help conserve pollinators. The launch was held at the Royal Society and was attended by many influential people, including shadow and incumbent environment ministers. Former Prime Minister Tony Blair speaking to the launch stated that the declining populations of pollinators are “fundamentally important to the environment and the country” and “It’s the next generation that will live with the consequences, if our stewardship of the environment is not properly maintained and we don’t live up to the obligations we have”.

As part of efforts to ‘Get Britain Buzzing’ the Pollen Nation project, in partnership with Anglian Water, York City Council and the Cooperative, aims to get companies, local authorities and the public to plant and maintain pollen and nectar sources in gardens and public spaces. In Britain bumblebees can be more plentiful in suburban areas than in the intensively managed countryside, so Buglife is encouraging specific wildlife management in such areas. A simple and genuinely beneficial measure is to provide bundled sections of bamboo or other hollow sticks, or drilled holes in logs to increase nesting opportunities for solitary bees and wasps.

Buglife, working with Living Roofs and funded by the SITA Trust has also constructed five ‘brown roofs’, also known as ‘biodiverse roofs’, on buildings across London, including the St. James Street tube station, headquarters of London Underground. The roofs are designed to provide feeding and nesting habitat for insects usually associated with ‘open mosaic habitats on previously developed land’.

Despite a severe recession, Buglife has continued to grow and develop. The charity has 20 staff, four of whom work from the office in Scotland. The charity is also developing its first regional office under the leadership of Andrew Whitehouse in Plymouth in South West England. Buglife has 30 member organisations and has never lost one (see appendix). With £600,000 spent on its charitable activities in 2010, the charity is set for another growth spurt thanks to funding from the Tubney Charitable Trust and is planning to take on a team of fundraisers and more conservation staff, particularly to have more capacity for saving sites.

4.7 The Future

In recent decades there has been great growth in the strength of the voluntary conservation movement and a decline in the nature conservation resources of the statutory agencies. The current big cuts to agency resources, starting in 2011, and continuing into at least 2 further years, will have profound consequences. Similarly, the NGOs live in uncertain financial times as Government measures to reduce the deficit take effect. This is already hitting funds such as the Aggregates Levy Sustainability Fund, an environmental hypothecated tax now switched to Treasury funds.

The only charitable sector in the UK with a lower proportion of Government income than nature conservation is ‘religious charities’. Only a tiny percentage of philanthropic giving goes to the environment. Even funds that appear to be for ‘biodiversity conservation’ are impossible to access for this purpose because they place such high priority on engaging large numbers of people that small projects are refused and large projects become uneconomical. Hard-nosed, science-based conservation, gathering data, managing habitats, and influencing decision makers simply fails to tick the children/youth, local people, ethnic minorities, and disadvantaged groups boxes, so most funding applications fail. However, funding bodies are just decision makers and Buglife has been influencing them with some success. It is difficult to be certain, but a number of funders that Buglife has set out to persuade to support the charity’s aim have subsequently funded invertebrate conservation activity by Buglife or others.

There will probably be even further disarray in the statutory conservation sector. The Welsh Assembly is very likely to merge the Countryside Council for Wales (CCW) with the Welsh arms of the Forestry Commission and the Environment Agency; in principle sound logic (for economic and practical efficiency) but running the risk that wildlife expertise and focus will be further diluted. In England, Natural England has been repeatedly reorganised, now has no Chief Scientist and has been drawn more closely to Government so that in practice it is unable to speak out without the permission of Defra. While a commitment from Defra to review the notified features of SSSIs and an attempt to fill any gaps in the series is promising, the lack of ambition for conserving species in the new England Biodiversity Strategy (Defra 2011), and general scantiness of supporting financial and knowledge resources, is a real worry. Defra's current approach is to put emphasis on creating new habitat, hoping that the specific needs of most endangered species will somehow be met through general habitat management measures, with only a small number of species needing specific management. Past experience suggests that such a simplistic approach is misguided.

Meanwhile the spatial planning system is in the process of radical reform that will introduce a presumption in favour of 'sustainable development' (without defining what sustainable development means), a thinning of the wildlife guidance down to a few paragraphs, and the devolution of the planning decisions to local authorities so small that they do not employ an ecologist.

A considerable effort is required to identify the most important invertebrate sites, and determine which ones should be protected by the SSSI system. In the meantime there is a growing time gulf on updating Red Data Book statuses and a major shortfall in the funds available to save invertebrates listed as BAP Priority Species.

At an even more fundamental level museum taxonomists are still being made redundant and identification skills are increasingly scarce in universities. Buglife has given evidence on the importance of supporting taxonomy to two House of Lords committees (Anon 2002 and Science and Technology Committee 2008). It is hoped that the 19 recommendations in the recent report 'Developing a National Strategy in Taxonomy & Systematics' (NERC 2011), written by panel of nine taxonomy scientists chaired by Buglife Vice-President, Professor Charles Godfray, will be implemented and the science that underpins biodiversity science will be enhanced.

While Buglife has made progress with a couple of the potential chemical threats that invertebrates face, there are others still awaiting time and resources to enable sufficient effort and focus to make a difference. This includes the effects on dung and pasture fauna from wormers such as avermectins, and the risks posed to aquatic life by Permethrin flea treatments for dogs and human medicines such as paracetomol and fluoxetine (best known as Prozac).

In the current spending climate conservation efforts are more dependent than ever on NGOs. However, the truth is that the UK and the EU missed the 2010 target to 'halt biodiversity loss' by some distance. Despite long-term growth and flexible funding sources, NGOs do not currently have the capacity to fully address the loss of biodiversity. Unless there is a shift in commitment level from Government we will also miss the 2020 target of "halting the loss of biodiversity and the degradation of ecosystem services in the EU and restoring them in so far as feasible". It is going to take a lot of hard work to take advantage of what opportunities there are and to also press for that better deal for wildlife.

The challenges that invertebrates face are of course not particular to the UK. Buglife would like to help to take forward invertebrate conservation on the international stage. Ultimately there would be justification for a global network of invertebrate conservationists in a format similar to Birdlife. Buglife wants to follow the paths of Butterfly Conservation Europe and Plantlife International in raising awareness and developing a partnership with like-minded individuals and organisations in other countries.

A decade on from the ‘Unity of purpose’ meetings the UK invertebrate conservation movement is far stronger, but the challenges invertebrates face seem only more vivid and Government has got some catching up to do. The need for, and purpose of, Buglife is even more important now. Buglife was spawned from the significance of the word biodiversity, a word popularised by renowned entomologist Edward O Wilson, also a Buglife Vice President. Buglife has carried forward the initial consensus-based approach through which it was established and now acts as a unifying agent for invertebrate conservation activities, working in partnership with many of its own member organisations, including new ones such as the highly successful Bumblebee Conservation Trust, established in 2006 and already with seven staff members. Perhaps more than anything else Buglife has been, and is, a high profile, determined and passionate advocate for invertebrates, the small things that run the world.

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Appendix – Buglife Member Organisations 2011

Amateur Entomologists’ Society
Badenoch and Strathspey Conservation Group
Balfour-Browne Club
Bees, Wasps and Ants Recording Society
Biological Recording in Scotland (BRISC)
British Arachnological Society
British Dragonfly Society
British Entomological & Natural History Society
British Myriapod and Isopod Group
Bumblebee Conservation Trust
Butterfly Conservation
Central Association of Bee-Keepers
Conchological Society of Great Britain & Ireland
Derbyshire & Nottinghamshire Entomological Society
Dipterists Forum
Edinburgh Entomological Club
Flora Locale
Grasslands Trust
Lancashire and Cheshire Entomological Society

People's Trust for Endangered Species
Plantlife
Pond Conservation
Royal Entomological Society
Royal Society for the Protection of Birds (RSPB)
Staffordshire Invertebrate Group
Sussex Biodiversity Records Centre
Watford Coleopterist Group
Wildlife Trusts
Wild Trout Trust
Yorkshire Naturalists Union

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Chapter 5
Insect Conservation in the United Kingdom – The Amateur Entomologists' Society

David Lonsdale

5.1 Early Days

The Amateur Entomologists' Society (AES) was founded by Leonard Tesch (initially as the Entomological Exchange and Correspondence Club) in 1935. Long before then, entomologists had been concerned about the decline of various species, or of insect populations in general. It is therefore not surprising to find an expression of such concern in one of the earliest publications of the society. Tesch (1935a) wrote of his impression that insects had generally become less abundant over the preceding 25 years. He had been seeing far fewer moths, especially at indoor light, than in the days when… 'it was quite usual to have a dozen or more moths flying about one's room….'.

Less than 2 years after founding the club that became the AES, Leonard Tesch (Fig. 5.1) was forced to step down because of unexpected commitments. Beowulf Cooper, together with his friend Norman Brangham, stepped into the breach and ensured the survival of the society (Brangham 1985). Indeed, Cooper kept the society active throughout the war years, when the first of the AES monographs and the first *AES Bulletin* in its present form appeared in 1942, 1943 and 1944 respectively.

At an AES Council meeting in 1947, Cooper proposed a new essay competition, open to all entomologists, in order to provide a manuscript for a leaflet on the 'Protection of British Insects'. His personal offer of a 9-drawer cabinet as first prize suggests that he did not anticipate the misplaced arguments that, in later years, would increasingly drive a wedge between 'conservationists' and 'collectors'. The Council agreed, however, also to discontinue the insect-setting competition at the society's annual exhibition. Mr Calverley, another Council member, offered C.B. Williams' 'Migration of Butterflies' as second prize for the 'insect protection competition'. It was also around this time that the AES came to be represented on

D. Lonsdale (✉)
Conservation Secretary and past President of the Amateur Entomologists' Society,
33 Kings Road, Alton, Hampshire GU34 1PX, UK
e-mail: d.lonsdale2@btinternet.com

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Fig. 5.1 Leonard Tesch with a group of pupils (Photo kindly provided by Martin Jacoby)

national conservation committees, an activity that continues to the present day, as mentioned in detail elsewhere in this chapter.

The 1950s and 1960s saw growing concern about the effects of modern agriculture on wildlife, especially after the publication of Rachel Carson's 'Silent Spring' (Carson 1962) which set alarm bells ringing about the effects of persistent insecticides on non-target species. Public attention was, however, mainly directed towards birds and other vertebrates. Meanwhile, amateur entomologists had seen signs of decline in many insect species following World War 2. More than 30 years after the war, Haes (1978) wrote in the *AES Bulletin* about the fragmentation of habitats of orthopteroid insects; habitats that had been abundant in old pasture, marsh and wasteland during pre-war agricultural depression and wartime neglect. Since, however, some of these sites were ploughed to increase wartime food production, it seems likely that some loss of habitats could be dated back to that time.

In 1967 Mr. S.J. Whitehouse and Sir Robert Saundby set up a Junior Conservation Prize (£2/10/-), to be awarded annually to an individual or group of junior members who had carried out a conservation project and submitted a report to the *AES Bulletin*. Following a lack of entrants in the first year, a list of ideas for projects was published in the May 1968 issue of the *Bulletin*. The list was, however, perhaps rather challenging for young entomologists; this might explain why there seems to have been no further mention of the competition.

By the time that the Junior Conservation Prize was offered, there was a new AES group that would eventually become the focus of conservation within the society. Its history is outlined under the next heading.

5.2 The AES Conservation Group and Conservation Committee

In 1965–1966, Ken Willmott set up the AES Breeding Group with the aim of reinforcing populations of Lepidoptera in the wild – a somewhat controversial activity, as mentioned elsewhere in the present chapter. Later, the AES Council agreed to provide support, on condition that the group would widen its scope to cover conservation in general and to include 'other' insect orders.

The group was required also to be supervised by two AES Council members and to submit annual reports. Thus, in late 1967, a newly constituted group (the Amateur Conservation Group, renamed 2 years later as the AES Conservation Group) was formed. Ken Willmott recruited Bill Parker as secretary of the revamped group, with a remit to set up new sub-groups for Coleoptera, Hymenoptera and Odonata.

Bill Parker was especially concerned about the widespread ignorance of the importance of dead wood for insect habitats. He therefore decided that beetles should be the first of the 'other orders' to be included in the work of the group. Meanwhile the present writer had begun running a 'Coleoptera Conservation Section' of the British section of the USA-based Teen International Entomology Group (TIEG). In response to a suggestion from Bill Parker in 1968, he transferred the TIEG Coleoptera section to the Amateur Conservation Group and began recruiting members from among the AES membership.

In 1969, Ken Willmott left the group to work with the British Butterfly Conservation Society, which had been founded in 1968 by Robert Goodden of Worldwide Butterflies. The group, by then renamed as the 'AES Conservation Group', soon afterwards published its first bulletin, edited by Bill Parker.

In 1970 (European Conservation Year) an AES Conservation Group committee was formed and the annual subscription was set at 2s 6d (12½ p after decimalisation in 1971). A list of 56 members, including one in Switzerland, was circulated. The present writer succeeded Bill Parker as secretary of the group and as editor of its bulletin. At that time he corresponded with and met Bob Pyle, who was working in the UK before his return to the USA as a co-founder of Xerces, the American invertebrate conservation society in 1971 (see Chap. 7).

The AES Conservation Group ran a field meetings programme during the 1970s, which continued as a general AES programme from 1980 onwards. The meetings enjoyed varying degrees of success, as measured by attendance. In order to spread the workload, the group committee appointed Pete Holdaway to a new post of field meetings secretary in 1983. Owing to decreasing attendance, however, fewer field meetings were held, with the notable exception of a series of 'task work' sessions under the direction of Peter Cribb in 1983 and 1984. Since 1973, he had been organising such sessions for members of the Conservation Corps, in order to undertake conservation management at Ditchling Common, Sussex, where the Marsh Fritillary butterfly *Euphydryas aurinia* was then present.

The group held annual general meetings, which included talks by invited speakers. In 1971 one of the speakers was Brian Benham, a written version of whose presentation was later circulated as a supplement to the Group's bulletin and then re-published 2 years later in the main *AES Bulletin* (Benham 1973). On the basis of his research on the Large Blue butterfly *Maculinea arion* in Devon, he thought that species-distributions were likely to shrink because of a lack of dispersal between isolated colonies and a consequent lack of genetic variation (see also Muggleton 1968). He predicted the extinction of the Large Blue in the UK by 1980 at the latest. This eventually happened in 1979 but the species was later re-established very successfully following further research (Thomas 1976), which showed that the larval-ant association was dependent mainly on the presence of *Myrmica sabuleti*, a species which requires hot, dry habitats in closely grazed areas. There was some subsequent AES correspondence as to whether the specificity of the ant-association was the only key factor (Gardiner 1976; Benham and Muggleton 1977).

Eventually, on 1 January 1980, the group was dissolved but only because the AES Council had decided that conservation should become one of the society's main activities, potentially involving all its members. The group's committee had already been working as an informal subcommittee of the AES and liaising with the society's representative on the Joint Committee for the Conservation of British Invertebrates (JCCBI), Graham Howarth. From 1980 onwards, it was reconstituted as a formal committee of the Council.

Much as amateur entomologists enjoy attending field meetings and exhibitions, they tend to pursue most of their activities alone. The society has, however, attempted to improve communication between members who are involved in conservation, with a view to enabling them to learn from each other's experiences. Simpson (1980) suggested that members could play a greater role in local conservation projects, for example by giving entomological advice to managers of nature reserves and by participation in practical management. Cook (1984) gave detailed advice about the need for conservationists to understand the planning system.

Meanwhile, with the formal recognition of conservation as a central part of the society's activities, the present writer was appointed to a new post of AES Habitat Conservation Officer on 1 January 1980. Over the next few years, officers were appointed to new posts in order to develop the society's conservation activities. Towards the end of 1987, Clive Betts became the Habitat Conservation Officer, joining the AES Conservation Committee, whose other members were Colin Hart (Chairman), Peter Cribb, Chris Buckingham, Clive Eastwood, Pete Holdaway, Stephen Miles and the present writer.

Clive Betts set up a scheme involving the appointment of area representatives, in order to aid co-operation between the society and the county or regional wildlife trusts (then mostly known as 'naturalists' trusts'). By 1991, he had recruited 15 volunteers, some of whom later began to meet annually at the instigation of Martin Harvey, who succeeded him in 1993 and managed to recruit a further 2 volunteers. The meetings took place in parallel with the society's annual exhibition at its present venue of Kempton Park Racecourse until facilities ceased to be available for the purpose. In subsequent years, perhaps owing to increasingly complex lifestyles, the volunteers have been less active but their role has to some extent been overtaken by developments, such as the founding of Buglife – The Invertebrate Conservation Trust.

Martin Harvey was succeeded in 1999 by Peter Sutton, who later also co-edited the *AES Bulletin* and has contributed many outstanding articles of conservation interest, including a series on classic entomological sites in Britain.

5.3 AES Policies, Representation and Viewpoints on Legislation

In addition to its long-standing contributions to the work of Invertebrate Link and its precursor-committees, the AES has developed policies relevant to conservation. The society's conservation policy, first issued in 1980, (AES 1996) was followed by an additional policy on insect collecting and conservation (AES 1983). When rules on licensing were introduced for traders using the society's facilities, a trading policy was also adopted (AES 1997). The AES has also contributed to numerous consultations, both local and national, in the UK. In 1970 – European Conservation Year – the present writer took the opportunity (rather naïvely) to submit proposals for insects to be accorded equal status with vertebrates in the formulation of government conservation policy. His proposals were dismissed on the grounds that the society was not a suitably constituted organisation, but he sent similar proposals to the UK Department of the Environment in preparation for a conference that took place in Stockholm in 1972. A resulting UK Government publication listed the AES as a contributing organisation but the only reference to insect conservation was, regrettably, a proposal for a blanket ban on collecting (Anon. 1972).

In 1980, when a new Wildlife and Countryside Bill came up for consultation, the AES contributed to the JCCBI's submission of a detailed set of comments. Also, the society sent letters to selected Members of Parliament and Peers, suggesting that the Bill should be strengthened with regard to the protection of insect habitats, but without unduly restricting the taking or possession of specimens. As explained later in the *AES Bulletin* (Lonsdale 1982a, b), the society's Conservation Committee was particularly concerned that effective protection of Sites of Special Scientific Interest (SSSIs) was to be provided only for 40 'star' sites. There was concern also that the listing of species for protection was intended mainly as an instrument for criminalising their collection, rather than safeguarding their habitats. During a parliamentary debate, Tam Dalyell MP quoted from the AES correspondence, having previously invited the present writer to lunch at Westminster to discuss the issues and to attend a committee session.

With pressure from many quarters, the Bill was strengthened in its provisions for protecting SSSIs, albeit with a major loophole, by which the Nature Conservancy Council (NCC), having notified a landowner of an intention to designate a new SSSI, was powerless to prevent damage to the site for 3 months thereafter. This loophole, which the society had identified at the consultation stage, elicited wide criticism and was closed in subsequent legislation. The attempts of the society and of the JCCBI to improve the Bill specifically for insect conservation were, however, unsuccessful. After its enactment in 1981, Stubbs (1982) wrote a fairly positive report for the *AES Bulletin*, from his perspective as a member of the Chief Scientist's Team in the NCC. Several years later, he was largely responsible for establishing the very helpful principle that species can be selectively listed for different aspects of protection, thus removing the need to criminalise the taking or possession of specimens where this is inappropriate.

Although amateur entomologists welcomed some aspects of the 1981 Act, there was concern about the balance that it struck between habitat conservation and anti-collecting measures. In the *AES Bulletin*, Lonsdale (1982b) wrote: '…*all our efforts were to no avail, and the Act has now enshrined in law the notion that rare insects can be better protected by making their collection illegal than by protecting their habitats*.' Editorials in the *AES Bulletin* (e.g. Gardiner 1982) called for change in government policies that had favoured the destruction of habitats through the intensification of agriculture, while failing to provide adequate support for the NCC. Many years later, correspondents continued to express their concern about laws that were failing to protect habitats, while demonising collectors.

Despite concerns about weaknesses of the Wildlife and Countryside Act 1981 for site protection, two young AES members (Reavey and Reavey 1983) were able to contribute an *AES Bulletin* article about their role in securing the first ever Site Protection Order under the Act. This was at Baddesley Common/Emer Bog in Hampshire, an existing SSSI which had come up for sale and was under threat without the new protection available under the Act. The county wildlife trust managed to buy the 61-acre bog. The Reaveys' message was that, as soon as an important invertebrate habitat is threatened, it is important to contact the Local Authority, the County Trust and the national statutory agency.

5.4 Local Projects and Campaigns

Accounts of various projects and campaigns involving AES members can be found in editions of '*Invertebrate Conservation News*' (*ICN*) and the earlier 'Group Bulletin'. The society's involvement in local campaigns and projects has always depended on the dedication of relatively few local members, as in the case of Ditchling Common, Sussex, the home territory of Peter Cribb (in whose name the AES established a conservation award after his death in 1993). In some instances, however, the society has lent support by writing letters to the relevant organisations. In other cases, like that of Walthamstow Marshes in north-east London or Brass-side Ponds in Co. Durham, the society's main role was to publish news of campaigns in *ICN* or the *AES Bulletin*. In a few cases, such as that of Kersal Dale in Greater Manchester and Abney Park Cemetery in north-east London, the AES gained publicity through television or radio interviews.

Walthamstow Marshes, a semi-natural wetland, was rescued from a proposed gravel extraction scheme only when AES member Brian Wurzell and others managed to provide evidence (contrary to ornithological views) that the existing floristically rich wetland, supporting a wide range of invertebrates, was of greater ecological value than the gravel pit lakes that would have replaced it (Wurzell 1980). AES members were involved also in a campaign to save Borstal Marsh, Kent from the development of an ice skating ink and a marina (McLean and Parsons 1984). The importance of providing good entomological evidence in defence of threatened habitats was again stressed by Betts (1993), reporting the success of an anti-road-building campaign in Devon. He added, however, that another (equally damaging) road scheme had later been approved and that the influence of the 'road lobby' was evidently as strong as ever in government circles.

In recent years, other organisations have become more aware of the range of habitat requirements of invertebrates. Thus, the role of the AES has to some extent shifted away from campaigning and more towards co-operation, as in the example of a project for the survey of a conservation grazing site at Headley Heath in Surrey (Ruffle 2009).

5.5 Amateur Entomologists in the Wider Conservation Movement

Although many amateur entomologists have worked locally to resist harmful site developments, they have generally been slow to co-operate at regional or national levels to improve the 'Cinderella' status of insects and other invertebrates in the conservation movement. The situation has improved considerably in recent years, but it was still dire in 1971. At a meeting of the AES Conservation Group in that year, John Muggleton presented a paper on the role of county trusts in UK insect conservation. In his paper, later re-published in the *AES Bulletin* (Muggleton 1973), he observed that insect conservation was then occupying a very small part of the activities of most of those trusts. He urged greater co-operation between them and entomologists, with a view to improving the situation.

Perhaps the past lack of entomological influence owes something to a sense of alienation that many entomologists have felt vis-à-vis conservation bodies that are concerned principally with species other than invertebrates and that – sometimes for good reasons – have promoted anti-collecting policies.

5.6 Role and Representation of the AES on National Committees

In 1947 N.D. Riley invited the AES to be represented on the Committee for the Protection of British Insects (CPBI) which, as mentioned elsewhere, was formalised under that name early in 1948. Despite the committee's name, there were already proposals that conservation should be based on ecological principles, instead of being concerned only with the preservation of sites or with the control of activities such as collecting and the use of newly emerging pesticides (Anon. 1947). In June 1947 the AES Council appointed Mr. E.E. Syms as the society's representative, while deciding to contribute one guinea to the Committee. Mr. Syms remained in post until 1952 and was succeeded in March 1953 by Graham Howarth.

When, in 1958, the Entomological Liaison Committee of the Nature Conservancy effectively replaced the CPBI, Howarth continued as the society's representative. He found, however, that he was working in isolation from the membership. Although various members were writing to the editor of the society's *Bulletin* to express their views about conservation, none of them had ever made contact with their representative before 1961 (Howarth 1961). Having drawn attention to this apparent lack of involvement, he was, however, later rewarded with communications about various sites and species under threat.

Graham Howarth was still in post in 1968, when the Liaison Committee was, in turn, succeeded by the JCCBI (Howarth 1969). From the early 1970s onwards, he liaised with the AES Conservation Subcommittee (an offshoot of the Conservation Group), in order to develop an increasingly active role for the society on the JCCBI. In 1976 he was succeeded on the JCCBI by Nick Cooke and then, in 1979, by Colin Hart.

Following the formation of the AES Conservation Committee in 1980, the society's representatives on the JCCBI were assigned a more active role than hitherto. The present writer joined Colin Hart in representing the AES. In their 'pink paper' (described elsewhere in the present chapter) they proposed the formation of a JCCBI Executive Subcommittee and they both joined it when it was formed in 1985 under the chairmanship of Paul Whalley. Through the present writer's work on the subcommittee, the AES has been involved in the preparation or redrafting of various JCCBI/Invertebrate Link papers. This involvement included a principal role in the drafting of the JCCBI policy on the role of legislation in aspects of conservation (Invertebrate Link 2008) and in assisting subcommittee member Steve Brooks in the drafting of the JCCBI Survey Guidelines (Brooks 1993), a printed edition of which was later published by the AES on behalf of the JCCBI.

The AES similarly played a major role in the revision of two of the main publications of Invertebrate Link: the codes for collecting and for reintroductions (translocations) of species. The first edition of the widely acclaimed 'A Code for Collecting Insects' (JCCBI 1972) was drafted principally by Michael Morris and Alan Kennard. By the late 1990s, the code required revision for various reasons, including the broadening of the remit of JCCBI to include all terrestrial and freshwater invertebrates. The revised version (Invertebrate Link 2002) is now known under a slightly different name. The equally well acclaimed, but perhaps slightly less well-known 'Insect Re-Establishment – a Code of Conservation Practice' (JCCBI 1986), drafted mainly by Michael Morris, also eventually required some revision. The revised version (Invertebrate Link 2010) allows for the inclusion of 'other' invertebrates and takes account of other related codes and guidelines. Also, it recognises a newly perceived role of translocation in the face of climate change.

The AES has been involved with various other national organisations or consultative panels, either as a subscribing member or by active representation. Having appointed a representative to the BCPI in 1947, the society became a member of the Council for Nature a year later. In the meantime, it had been invited to join the British Committee for International Nature Conservation but the Council declined on grounds of cost, while recording its agreement with the aims of the Committee.

As a voluntary organisation, the capacity of the AES to be represented on committees or at conferences has been limited according to the availability of individuals who are in retirement or in a position to take leave from employment. Nevertheless, the society has been represented at numerous events, including some that took place during the early days of the AES Conservation Group. In 1969, for example, David Corke represented the society at a meeting of the National Biological Societies, organised by the BRC on the theme of biological recording and surveys. In the same year, Roy Hilliard attended an exhibition displaying the work of the Nature Conservancy of Bulgaria (Hilliard 1970).

The society has presented posters at various conferences, including the Royal Entomological Society (RES) symposium 'The conservation of insects and their habitats' in London in 1989 and the annual conferences of the RES in 2006 (Bath), 2008 (Plymouth), 2009 (Sheffield) and 2010 (Swansea). Also, a poster comparing the resources devoted to invertebrate vs. vertebrate conservation in the voluntary sector was presented at a Zoological Society symposium (Lewis and Lonsdale 2007).

In 1999 the AES took part in a government review of the effectiveness of the Wildlife and Countryside Act 1981 in protecting scheduled species (as distinct from the quinquennial reviews of the species listed in the schedules). The resulting report demonstrated a consensus that most of the species protected under Schedule 5 (i.e. animals other than birds) were threatened far less by collecting than by the destruction, degradation and fragmentation of habitats and by the wider threats of pollution and climate change. In the same year, the AES and JCCBI were involved also in consultations over the drafting of voluntary codes of conduct for mushroom pickers in England and in Scotland. The entomological interest concerned the numerous species that require fungal habitats.

5.7 The AES and the Formation of Buglife – The Invertebrate Conservation Trust

In November 1984, the AES submitted a JCCBI discussion paper (known as the 'pink paper' because of the colour of the paper that happened to be available), proposing a debate on the need for a new structure or organisation to promote insect conservation on a day-to-day basis. The paper acknowledged the valuable roles of the JCCBI, including the production of authoritative publications such as the code for insect collecting and the code on reintroductions (then nearing completion). The JCCBI was, however, in need of a fundraising mechanism and lacked the capacity to promote insect conservation on a day-to-day basis.

At the March 1985 meeting of the JCCBI, a decision was made to adopt one of the recommendations of the AES pink paper: to establish a JCCBI Executive

Subcommittee in order to react more quickly to current business and events. It was, however, not until 1990 that the JCCBI was able, with the aid of indirect commercial sponsorship, to appoint a part-time Conservation Officer, as recorded elsewhere.

By the time that funding for the Conservation Officer's post came to an end in 1993, some members of the JCCBI proposed that the entire committee should be wound up, arguing that lack of funds had left it without the resources to play a useful role. This came at a time when there was a need to develop a UK strategy for invertebrate conservation (within what became the UK Biodiversity Action Plan) in compliance with commitments made at the 1992 'Earth Summit' in Rio de Janeiro. The AES perhaps had some unintentional responsibility for the mood of despondency that led to the winding-up vote, having occupied much of the committee's time with the drafting of the policy on the role of legislation in insect conservation (Invertebrate Link 1995, 2008), some aspects of which had proved contentious.

Rather than acquiesce to the winding-up proposal, the JCCBI decided to seek renewed support from the Royal Entomological Society, which proved to be forthcoming. Encouraged by these developments, the AES urged that the committee should revisit the society's suggested options of establishing either a new co-operative structure or a new organisation to promote insect (now invertebrate) conservation. Another AES suggestion was to hold a national symposium to debate 'a way ahead for invertebrate conservation in Britain'. The society's proposals were adopted. Thus, as recorded elsewhere in the present volume, the first conference took place in February 1996 and was followed by two others, under the general theme of 'unity of purpose'. They were held in Peterborough, where Alan Stubbs and other JCCBI members played a leading role in ensuring their success.

The AES took part in the conferences, committee work and consultations with numerous organisations that continued through the 1990s, culminating in an agreement that a new charitable trust should be established. As recorded in more detail elsewhere, the 'Invertebrate Conservation Trust' (later 'Buglife') was established at the end of the year 2000 (see Chap. 4). It is, however, doubtful whether the new trust could have been established but for the generosity of an anonymous donor. Nevertheless, the trust was formed in the knowledge that the environment minister, Michael Meacher, was sympathetic to the cause of supporting invertebrate conservation. This had become evident when the AES representative was fortunate enough to be allowed to raise the matter in public with the minister at a national conference of environmental organisations in June 1997.

5.8 'Invertebrate Conservation News' and Its Forerunners

Having set up the AES Breeding Group, Ken Willmott circulated a bulletin, which was followed in February 1967 by some 'Special Notes' and soon afterwards by the group's first 'Seasonal Letter'. The seasonal letter included some interesting comments from AES President Peter Cribb about the pros and cons of insect translocations.

In May 1969, group secretary Bill Parker issued the first bulletin of the newly named AES Conservation Group. It included the first of a series of subsequent editorials and articles on topics that, although not very fashionable at the time, gained in importance afterwards. For example, Hilliard (1969) argued that there was too much reliance on the preservation of 'typical localities, possibly one of each type'. Recognising that the long-term value of such sites could be limited because of adverse changes and events, he favoured the designation of a network of additional sites in order to favour the dispersal of species and to be within easy reach of amateur entomologists. In a previous *AES Bulletin* article he had stressed the need for habitat conservation in urban, as well as in rural areas (Hilliard 1967).

Ideas of conservation throughout the wider landscape, whether rural or urban, did not seem to be very fashionable in the late 1960s and early 1970s, and there were instances where little support could be gained for the conservation of sites that, despite being 'oases' of wildlife in ecological 'deserts', were not regarded as representing recognised biotopes. Roy Hilliard can therefore be regarded as something of a pioneer in advocating a change in national conservation strategy. His views were echoed in numerous editorials and articles in the Group Bulletin/*Invertebrate Conservation News*, including some (from 1972 onwards) that called for the protection and conservation of habitats on wasteland sites, much later to be known as brownfield sites, when this kind of conservation started to become more fashionable. Wasteland habitats (in the days before the coining of the term 'brownfield') were the theme for the group's display at the society's 1974 annual exhibition.

Old, 'neglected' cemeteries were among the urban wildlife 'oases' that were described in early editions of *ICN* (e.g. Lonsdale 1974). Their importance was also stressed by Peter Cribb (in professional life, the manager of a large crematorium), writing in the journal "Parks and Recreation", read by managers of urban open spaces. Long before the rise of groups dedicated to urban wildlife conservation, or of the Wildlife Gardening Forum (of which the AES is a member), *ICN* was drawing attention to the harm that can be done by tidying-up these sites, or by excessive tidiness of domestic gardens. The rôle of the latter as oases of urban habitat has, however, been eroded in recent years by housing re-development.

The conservation of deadwood habitats was a rather unfashionable theme when promoted in the earliest issues of the 'Group Bulletin'. Elton (1966) had highlighted the importance of such habitats, but ignorance remained entrenched and widespread. Stubbs (1972) provided a seminal guide to the conservation of these habitats, which helped to raise awareness. Later, he also contributed considerably to the deadwood habitat sections of the society's book habitat conservation for insects (Fry and Lonsdale 1991). Meanwhile, contributors to the Group Bulletin and *ICN*, including Stephen Miles and the present writer, continued in their attempts to promote awareness of deadwood habitats. Far more was, however, probably achieved through the subsequent work of Roger Key in English Nature's Veteran Tree Initiative in the 1990s and the continuation of this work by the Ancient Tree Forum, together with important studies of saproxylic invertebrates by Keith Alexander and others.

The first 'Group Bulletin' in 1969 was duplicated on a hand-operated Gestetner and the same production method was used long after the bulletin was succeeded, in

1980, by Insect Conservation News. The change from Group Bulletin to *ICN* was, however, marked by a modestly 'new look', owing to the use of a headed front page, showing the society's brimstone butterfly emblem on a chrome yellow background. With the exception of the third and fourth group bulletins, these publications have been compiled and edited by the present writer, who succeeded Bill Parker as group secretary in 1970.

The last of the 'gestetnered' editions of *ICN* (including a news item on the aftermath of the Great Gale of October 1987) was published in 1988. Publication then ceased for about 6 years, owing to pressure of work, but the workload was eventually alleviated by an arrangement whereby *ICN* became a printed centre insertion in the *AES Bulletin* in 1994. Under the slightly altered title of '*Invertebrate Conservation News*', it thus began to reach all members of the society. Before 1994, *ICN* was circulated to only a small proportion of AES members, who paid a separate subscription. It was (and still is), however, also sent to non-AES subscribers, as well as to other organisations in exchange for other journals. With the growth of a small overseas readership, *ICN* was registered under an ISSN number in 1987.

An indication of the range of topics that have been covered by *ICN* and the old 'Group Bulletin' since 1969 can be found in the contents lists of recent years, as shown on the society's website (www.amentsoc.org). Some of the items published in the Group Bulletin were concerned with the running of the group, but there were also editorials and news items that eventually began to appear under a fairly consistent 'house style', still used in *ICN*. This included an opening editorial, followed by 'general news, views and information'. A following section included items concerned with particular species or sites, while a final main section summarised the findings of selected items of research. A book review section was sometimes included, and there was often also a list of forthcoming events in the UK.

5.9 The *AES Bulletin*: Discussions and Articles on Conservation

Although *ICN* has long been the society's main vehicle for publishing articles on conservation, the *AES Bulletin* has also included many relevant items. Various *AES Bulletin* items are recorded in the sections of the present chapter that deal with the controversies about collecting, trading and the translocation of species. The articles on other subjects include a scholarly contribution on the distributions of species (Uffen 1960), which celebrated the society's first 25 years. Danks (1963a) later reviewed some related aspects of insect ecology. Meanwhile, in a thoughtful and still highly relevant article, Brangham (1961) analysed the motivations of entomologists to conserve insects.

The August 2002 issue of the *Bulletin* was especially conservation-orientated. In addition to an account of the editor's childhood bug-hunting in gardens (Sutton 2002a), it included articles on the conservation of the Silver-studded butterfly *Plebejus argus*

(Sutton 2002b) and a report on the second symposium and workshop on the conservation of saproxylic beetles (Sutton 2002c). Other frequently aired subjects have been the extinction of species and the destruction of habitats. An early example concerned adverse effects of modern forestry at Castor Hanglands near Peterborough (Showler 1951). Thirty years later, in 'Butterfly Year', the sense of loss was enough to prompt an 'obituary' for four butterflies that had become extinct in Britain during the twentieth century (Gardiner 1981). On a more retrospective note, AES member Malcolm Simpson submitted an account of the butterflies of the City of Cambridge, dating from 1883 (Walters 1883). Gardiner (1988) observed that nearly half of the species listed in 1883 were no long extant in the entire county of Cambridgeshire, let alone the city.

Another tale of loss was told by Townsend (1985), who described the status of Odonata on Southampton Common after the complete dredging of the largest of the lakes on the site. Many years later, Macadam (1998) wrote about the conservation of aquatic insects. In other *AES Bulletin* articles several years later, Sutton (2003a, b) reviewed the changing status of British species of Odonata.

At a time when the Forestry Commission was generally gaining a 'greener image', Gardiner (1986) criticised the large-scale planting of Lodgepole pine *Pinus contorta* in the peat bogs of northern Scotland. He observed that the Pine Beauty moth *Panolis flammea* was helping to reverse the process by killing large areas of the plantations. He was, however, concerned that the proposed release of a virus to control the moth would put non-target species at risk. On a more positive note, the Bulletin editor reproduced a report from 'Habitat' magazine about the success of a campaign (which had involved AES member Peter Cribb) to save Feltham Marshalling Yards, a habitat-rich site in south-west London, from housing development (Anon. 1990). Years later, the site was developed, but with the protection of substantial areas for wildlife. Another example of the role of individual entomologists was provided by Newnham (1990), who wrote about his apparently successful campaign to prevent detrimental summer mowing of his local area of common land. Similarly, Partridge (2002b) wrote about his efforts (with the aid of an impressive set specimen) to persuade site managers not to destroy habitats of the Goat moth *Cossus cossus*.

As well as campaigning to safeguard their local habitats, members of the society have occasionally been involved in research projects. For example, Dennis (1986) described the results of a study (involving boys from Manchester Grammar School) of the 'barrier effect' of a motorway on the movements of insects. There have also been studies of the habitat requirements of species listed under the UK Biodiversity Action Plan (e.g. Waring 1997). The number of research-related articles in the *AES Bulletin* increased during the presidency of Mike Majerus, who very sadly died while in office. These included a report on the first evidence that the exotic Harlequin ladybird *Harmonia axyridis* was causing a decline in British populations of the native two-spot ladybird *Adalia bipunctata* (Majerus 2008).

With increasing awareness of the need to conserve habitats in the wider landscape (i.e. not relying excessively on nature reserves), the *AES Bulletin* began to include articles on techniques such as the development of conservation headlands in arable land (Dover 1988). On the subject of nature reserves, their design in relation to insects was discussed in an article that questioned some of the wisdom that had been based on 'island biogeography theory' (Hollier 1988).

The *AES Bulletin* has published articles on insect conservation overseas, including a contribution by Parsons (1983) on insect farming in Papua New Guinea (PNG). He described its benefits for conservation (e.g. as an alternative to forest clearance for oil palm plantations), as well as for a third world economy. An accompanying article by Cooter (1983) highlighted the plight of the world's largest butterfly, *Ornithoptera alexandrae*, which was surviving in areas of PNG that were being logged for oil palm plantations. He urged AES members to express concern, in the hope of securing funds for research.

Several Bulletin articles have touched upon the fundamental principles of conservation. Young (1978) argued that efforts should not be devoted to the conservation of single species, except in special circumstances. Similarly, Wurzell (1981), with the reintroduction of the Large Blue butterfly in mind, argued that resources should be primarily devoted to relatively ordinary, easily accessible habitats, rather than to species that had become very restricted in their British distribution and yet remained common and widespread on the Continent. Various articles in the *AES Bulletin*, as well as in *ICN*, have been prompted by activities or campaigns that have annoyed entomologists. For example, Brian Gardiner (1999) spoke up in support of three species (ragwort, ivy and rabbits) that, despite being good for invertebrate habitats, were the subject of campaigns to control or locally eradicate them. In 2003 the AES joined a campaign to resist excessive measures proposed for the statutory control of ragwort in England.

5.10 Other Conservation Publications by the AES

Until 1991, the continuing publication of *ICN* and the old 'Group Bulletin' had been the society's main written contribution to conservation. There had, however, also been an AES pamphlet on habitats for garden butterflies (Cribb 1982). By the mid 1980s, various organisations had published methods for protecting and managing insect habitats either in journals or in leaflets. There was, however, no single book dealing comprehensively with insect conservation, at least in the context of cool temperate climates. The idea that the AES might publish such a book had seemed unrealistic when first considered in the 1970s, but there now seemed to be enough information and expertise to do so. The book (Fry and Lonsdale 1991), believed to be the first of its kind in the world, included contributed chapters from several expert authors and a foreword by HRH Prince Charles. It proved to be one of the society's best selling publications and had to be reprinted. Although currently out of print, it is still much in demand today, and a second edition is planned.

The AES was involved in another very successful conservation-related venture when it collaborated with English Nature in 1997 in publishing an educational slide pack, showing insects in four major types of habitat: heathland, grassland, woodland

and wetlands. The slides were accompanied by text written by Roger Key, who also provided a large proportion of the 48 excellent slides in the pack. The two organisations produced a further slide pack in 2001, covering habitats in uplands, farmland, coastal areas and 'brownfields'.

5.11 Encouragement of New Generations of Entomologists

In an *AES Bulletin* article, Partridge (2002a) expressed the sense of wonder and thrill that a child experiences when first discovering insects in the garden; a wonder that he suggested has something to do with the instinct to hunt. The society's role has always been to encourage young people to develop an interest in the natural world. Junior members have always been welcomed and there has been much to engage them at the society's annual exhibitions, which have taken place at various venues in the London area. Also, in the 1950s and 1960s, the society established links with the Schools Nature Study Union and to some extent with the Junior Naturalists' Association. More recently, the society has published story books for children, written by Sonia Copeland Bloom in the *Tales and Truth* series. The books include information on the conservation and keeping of the invertebrates that appear as characters in the stories.

The society has provided special services for junior members for many years, including a series of 'junior fieldweeks', beginning in 1985. In 2010, a 'young entomologists' day' (intended to be the first of many) was held at the Oxford University Museum of Natural History. Young members between the ages of 5 and 17 toured the museum and took part in a competition, in which they gave talks to an audience of about 80 people.

In 1996, the society's junior section became the 'AES Bug Club', with its own magazine, when the original Bug Club, founded 3 years earlier by the Royal Entomological Society (RES) under the leadership of Clive Betts, was taken under the wing of the AES. Since 2009 (again as 'The Bug Club') it has received renewed support from the RES through a partnership between the two societies. Its magazine includes items on conservation and has sometimes featured a 'conservation corner'.

From 2005 onwards, the AES has participated increasingly in 'outreach events', hosted by various local and national organisations, providing displays and 'bug hunts' in order to introduce children and their parents to conservation and other entomological activities. This initiative has been led principally by Dafydd Lewis, one of the society's representatives on Invertebrate Link (JCCBI). Some of these events, together with field meetings of the Bug Club, have been organised in conjunction with the RES National Insect Weeks in 2006, 2008 and 2010. Also the society's annual general meeting has in recent years also become a members' day, which includes many activities for Bug Club members. Unfortunately, there has been a trend (albeit perceived more than strictly quantified) for fewer youngsters to develop a lifelong interest in insects or other invertebrates. The AES founder, a schoolteacher by profession, suspected that potential naturalists were being discouraged by an anti-killing attitude that was being fostered in schools and societies (Tesch 1935b). Other factors, including heightened concerns about the safety of children and the distractions of electronic entertainment, have sadly had an additional negative effect in more recent years (Key 2006; Cheesman and Key 2007). The need to overcome such obstacles is now a major concern of Invertebrate Link, which held a conference on the subject in 2006.

5.12 Debates and Opinion-Forming in the AES

5.12.1 The Collecting Controversy

In the society's very early days, Tesch (1935b) commented on the controversy for and against the collecting of specimens. He doubted whether the acquisition of a few specimens for the cabinet could be harmful but he added that 'all true collectors' will deplore indiscriminate 'taking and killing of everything seen'. A few years later, his successor (Cooper 1938) found it necessary to reassure a correspondent that the society's field meetings would not be held indiscriminately in places where collectors could inflict permanent damage on insect populations. The controversy was, however, not new in the 1930s and can be traced far back into the nineteenth century, as pointed out by the *AES Bulletin* editor in the 1970s (Gardiner 1975).

As Tesch's (1935b) comments suggest, there was already a widely held view that over-collecting was largely a thing of the past and that its remaining manifestations, if any, represented an unacceptable face of entomology. In 1947, when the AES Council appointed its first representative on the nascent Committee for the Protection of British Insects, there was a proposal that R.B. Benson should be asked to prepare a leaflet for publication on protection matters, taking the line that 'collectors should be urged to become scientists' and so 'avoid the wanton destruction which had occurred in the past'. There was evidently a feeling that the perpetrators of such destruction – if such people still existed – were beyond the pale, whereas collecting per se, when conducted in moderation and for good scientific reasons was perfectly acceptable (e.g. Gilchrist 1970). This is probably a view that most entomologists hold today, and so it seems all the more unfortunate that a consensus of rationality and moderation has not always been apparent in the decades following the proposal for that AES leaflet.

Perhaps the polarisation of views was exacerbated in the wake of the Protection of Birds Act 1954, which comprehensively criminalised the taking of wild birds or their eggs, thus arguably creating a division between a law-abiding majority and a new kind of criminal underclass. Thus, public perceptions of 'right' and 'wrong' were perhaps altered with regard not only to birds but also to the more glamorous forms of insect life. Also, despite an apparently long-established consensus against unscrupulous collectors, misdemeanours were still occurring. For example, Riley (1952) felt the need to express regret that some entomologists had failed to heed a request to refrain from collecting Blair's Wainscot *Sedinia buettneri* from the Isle of Wight in 1951. He maintained that the activities of the local Council had done so much damage that the very greatest restraint was needed. Another AES correspondent (Bingham 1954) criticised the society's editor for publishing an article that could have guided unscrupulous collectors to the Toadflax Brocade *Calophasia lunula* at Dungeness.

In the 1960s, the collecting controversy was still dividing members of the society. The advent of mercury vapour traps was causing particular concern, with Danks (1963b) and Goddard (1967a) arguing that they were capable of depleting local populations. This view was, however, challenged by Robinson (1967). Of course, no one in recent decades has seen fit to argue in favour of over-collecting, but Coleman (1972) unashamedly extolled the joys of collecting for its own sake. In contrast, Willmott (1975) wove a vehement criticism of 'trophy hunters' into an article about the Purple Emperor butterfly *Apatura iris*. Others were concerned about his condemnatory stance, including Cooter (1976), who pointed out that extinctions and declines are caused by natural factors or by changes in land use, and should not be blamed on collectors in the absence of proper evidence.

Before the enactment of legal restrictions on insect collecting in Britain, Cribb (1971) advocated the rational approach that is now widely accepted amongst entomologists, i.e. that any ban on collecting should be limited to circumstances where it poses a demonstrable risk, owing to the vulnerable status of particular species (mostly brought about by habitat destruction).

The concept of rigorously selecting species for legal protection accords with the principles of modern risk assessment. In the first half of the twentieth century, however, it was considered impracticable by those who campaigned to strengthen legislation that had initially protected only selected vulnerable bird species (Bassett 1980). A few AES members have taken a similar view with regard to insects, arguing that reverse-listing (i.e. the criminalisation of collecting any species, except where the law dictates otherwise) is the only practicable approach. For example, Clarke (1978) argued that collecting insects was unnecessary and that it was setting a bad example to others. He also predicted that it would probably be outlawed within the next 15 years. He dismissed as 'pseudo-scientific reasoning' the moderate arguments of other correspondents in favour of conscientious collecting. Clarke's prediction of a total ban on collecting UK insects was not fulfilled when the Wildlife and Countryside Act 1981 replaced earlier legislation. The idea of reverse-listing British invertebrates was, however, later revived by one of the participants in the governmental review of the operation of the Act in 1999. Following this proposal, specialist advisers in the statutory agencies were quick to assure field naturalists that they would continue to support the listing only of species that were demonstrably at risk from collecting. By the end of the first decade of the twenty-first century, however, it was becoming apparent that the government was no longer willing to ensure the continued employment of invertebrate specialists in the agencies. There has therefore been a re-awakening of fears that legislators, lacking appropriate in-house technical advice, might come to regard measures such as reverse-listing as perfectly reasonable.

Although the draconian idea of reverse-listing has not been adopted for British invertebrates, there are certain clauses in the 1981 Act that have caused concern amongst entomologists, such as Tennent (1992). These include the ‘guilty until proven innocent rule’, whereby all specimens of fully protected species are assumed to be unlawfully held unless the holder can prove otherwise. In various other countries, the mere existence of legal restrictions has led to altercations between entomologists and the authorities. For example, an AES member wrote of being detained for 5 hours by French police, while returning with butterfly specimens lawfully collected in Morocco (Tennent 1994).

A number of entomologists in the UK have regrettably breached long-standing bylaws, many of which pre-date national legislation; for example in the case of the truculent behaviour of an alleged AES member, who had been challenged for collecting without a permit on Forestry Commission land (Howarth 1976). With altercations in mind, the warden of a nature reserve (Davis 1993) urged entomologists to seek permission before collecting on reserves, explaining that in most instances they were likely to meet with co-operation and to be welcomed for the records that they could provide.

Although AES members showed mixed responses to the enactment of legal restrictions in 1975 and 1981, they had evidently welcomed ‘A code for insect collecting’, published some years earlier (JCCBI 1972). The Code, last revised in 2002 (Invertebrate Link 2002), advises forms of restraint that go far beyond the requirements of UK law, but perhaps its acceptance owes much to its voluntary status. Nevertheless, the Code has evoked some debate in relation to long-established activities that seem to contravene it, such as the use of total-kill traps in the Rothamsted Insect Survey (Bell 1977). As recorded by M.G. Morris and O. Cheesman elsewhere in the present volume (Chap. 2), the JCCBI had agreed to differ with the Rothamsted Survey in this matter.

In the case of the Rothamsted Survey, the value of the resulting data was widely thought to outweigh the use of total-kill traps. Although killing was not strictly essential, some of the participants in the survey would not have considered other methods to be practicable. In many other circumstances, however, opponents of collecting have often argued that it is unnecessary, irrespective of whether it adversely affects insect populations. For example, Corke (1970) saw no justification for collecting the better-known taxa. Also, he argued that entomologists had a moral duty to leave beautiful insects for others to see, and that they should avoid perpetuating a public image of the bug-hunter. He was among several AES members who advocated cameras in place of nets, whereas others (e.g. Moseley 1979) argued that specimens had to be taken for the identification of many non-lepidopterous species. With the public image of entomologists in mind, Gardiner (1977) wrote of the hypocrisy of people who object to the use of butterfly nets and yet contribute to the destruction of wildlife on a much greater scale. Many years later, he reported that a reluctance to be seen carrying a net had been causing entomologists to submit incorrect records of species seen only at a distance (Gardiner 1996). In the same issue of the *AES Bulletin*, Emmet (1996) suggested that entomologists should seek to expose such hypocrisy when accosted in the field.

5.12.2 Controversy About Trading

Trade in insects, both dead and alive, has been much debated amongst AES members, alongside the related subject of collecting specimens. The sheer volume of trade, sometimes involving wild-caught rather than *bona fide* ranched or captive-bred specimens, has raised concerns about the unsustainable depletion of invertebrate populations. Also, some people have viewed the sale of dead specimens distasteful, irrespective of ecological considerations. This kind of trade grew more noticeable during the 1970s, when the society's annual exhibition (then being held in spacious accommodation at Holland Park School in west London) became increasingly dominated by trade stands.

In 1977, an opinion poll of the society's members showed an equal preference for trade stands and for members' exhibits. In 1991, following 10 years of confusion about the interpretation of trade-related clauses of the Wildlife and Countryside Act 1981, the AES Council issued a set of restrictions on trade in protected species at the society's annual exhibition. These restrictions went beyond legal requirements, in an attempt to avoid the uncertainties associated with licensing systems. Amid protests from traders and various members, the society later returned to a policy of simply upholding the law. Meanwhile, Alan Stubbs of the NCC clarified the official interpretation of some especially confusing aspects of the Act, regarding overseas and captive-bred specimens of scheduled species (Stubbs 1991).

Meanwhile, the balance between trade and exhibits at the society's exhibition had remained a matter for debate. Day (1982) advocated a total ban on the sale of any rare species caught overseas and of any rare Lepidoptera caught in Britain. Wurzell (1982) responded by drawing attention to the practical difficulties in deciding which species might qualify as rare in this context. Also he pointed out that traders' perfect specimens were often being obtained by captive-breeding or ranching. He suggested that the display of official trading certificate or licences would allay fears about the exploitation of wild-caught rare species.

In addition to being a platform for the exchange of views about trade, the *AES Bulletin* published an informative article by Mark Collins, reviewing the international trade and collecting, both private and commercial, of Swallowtail butterflies (Collins 1985). The article was an abridged extract from a recently published IUCN Red Data Book (Collins and Morris 1985). In 1997, as suggested earlier by Wurzell (1982), the AES introduced a requirement for traders to display the relevant licenses or permits for all species covered by UK or international law on trade (AES 1997). This followed an incident in 1993, involving police action against suspected illicit traders at an event of another organisation: the Christmas Entomological Fair in Leicester. The *AES Bulletin* published two somewhat different accounts of that incident; an expression of concern from the editor of the Entomological Livestock Group (Batty 1994) and an explanation of the legal background and of the role and stance of English Nature (Sheppard 1994).

5.12.3 Translocation of Species

The translocation (or ‘transplantation’) of species was another topic aired in the very early days of the society’s Bulletin. Tesch (1936) quoted extracts of a paper on the subject by Mr. J. Walker (a member living in Devon). Mr. Walker had unsuccessfully attempted to ‘re-colonise’ the Adonis Blue *Lysandra bellargus* at a site called Anstey’s Cove (using Kentish stock), following the gradual disappearance of this butterfly from this and other sites in the Torquay district in the first decade of the twentieth century. He also reported an early attempt to translocate the Five-spot burnet moth *Zygaena trifolii* from a site that had been earmarked for construction near Paignton. In 1896, he had translocated all the larvae that he could find to ‘similar ground’ at another site. Two years later, the species was still present at the new site, but it seems that Mr. Walker had not returned to check whether they had persisted to the time of his report in 1936.

At various times from the late 1940s onwards, there were calls for entomologists to record and report translocations, if only to help avert the creation of false records (Riley 1947; Howarth 1964). Evidently, opinions were divided between strong proponents of ‘putting down’ such as Curran (1958), strong opponents such as Taylor (1958) and qualified proponents such as Cribb (1959).

By the 1960s, it was widely realised that many factors ought to be considered before attempting to release insects into the wild for reintroduction or for reinforcement of populations. Cribb (1969), writing in the *AES Bulletin* about the conservation of the Purple Emperor butterfly *Apatura iris*, was aware of the need to ensure that potential receptor sites should be assessed for suitability of habitat. He had identified key factors of suitable habitat and had been releasing captive-reared stock into apparently suitable localities in Surrey. Soon afterwards, however, he published an article on the drawbacks of such activities if appropriate precautions and consultations were not observed (Cribb 1970). With regard to the Large Blue butterfly, he realised that any such projects would need to take account of the ants that provide an essential habitat for its larvae. His studies of the habitats of this species in the 1950s serve as an example of the potential role of amateur observers (Cribb 1958).

The need for caution in translocations was stressed by Goddard (1966, 1967b), who suggested that artificially bred specimens, perhaps being genetically unfit for survival in the wild, could weaken the fitness of receptor-populations if released for reinforcement. Muggleton (1968) countered by arguing that released specimens could help to restore gene flow between isolated vulnerable populations. Wurzell (1978) agreed with another correspondent (Bryan 1978) that translocations were potentially valuable, in the face of natural (e.g. climate-induced) colonisations or extinctions, together with anthropogenic changes. He disagreed, however, that a liberal attitude should be taken towards introductions of continental stock into the UK. Hanson (1979) was also in favour of translocations, but objected to the negative view of conservation as a form of ‘fossilisation’ (i.e. by trying always to maintain the status quo at sites).

5.12.4 Artificial Lights and Bird-Feeding

The effects of artificial light on insect populations – a highly topical subject today – were discussed in the early days of the society. Tesch (1936) quoted Beowulf Cooper with regard to the attractiveness to insects of different types of lighting, as determined by the spectral range. Cooper speculated that certain species were disappearing because of their failure to survive after being attracted to the bright lighting that had already become commonplace in street lamps, motor cars and houses. If, in the 1930s, motor cars were thought to be destroying significant numbers of insects in their path, there is probably more reason to suspect this nowadays, when the car 'population' is very much greater. As discussed in various editions of *ICN*, problems can now also be caused by the use of newer inventions, such as solar panels and (where outdoors) electrocution traps.

The boosting of garden bird populations by artificial feeding is another conceivable factor in the decline of insect species that has been considered by AES members, including Corke (1967).

5.13 Summary and Conclusion

The AES has been concerned with conservation since its early days and has promoted it for many years through a range of activities. These have included publications, other educational work, active participation in Invertebrate Link, and an involvement in the protection and management of particular sites. Also, by providing a forum for the discussion of ideas and opinions, the society has helped in the development of principles for the conduct of practices such as the collecting and trading of specimens. It is hoped that the society's work in encouraging new generations of entomologists will help to ensure a future role for entomologists in conservation. Although conservation is a major activity of the society, it is only one among many. The society therefore welcomed the establishment of Buglife – The Invertebrate Trust and looks forward to a continuing and productive relationship with the Trust.

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Chapter 6
Butterfly Conservation: The Development of a Pioneering Charity

Martin Warren

6.1 Introduction

Butterfly Conservation is a registered charity in the UK whose aim is to conserve butterflies, moths and their habitats. It currently (September 2010) has 15,000 members, over 55 staff, and 31 volunteer Branches throughout the UK. Although much of its work is based in the UK, it helped establish Butterfly Conservation Europe in 2004, to stimulate and co-ordinate action across the continent. The following is a personal account of its development, taken from articles and observations that were gathered for the charity's 40th anniversary in 2008.

6.2 The Early Years

On a September evening in 1967, a small group of amateur naturalists met in London at the flat of Thomas Frankland in Montagu Square. They were concerned about the plight of butterflies and decided to take action to save them by forming a society where they could gather like-minded people to help them. The British Butterfly Conservation Society, as it was then called, was registered as a charity on 7th March 1968 and inaugurated on 5th April by an announcement in the Observer newspaper. Its principle objective was 'the study, protection and preservation from extinction of natural fauna and flora, and particularly all species of British butterflies and moths'.

The founding members and initial driving forces were Thomas Frankland and fellow naturalist, Julian Gibbs. They had both been interested in breeding butterflies since their childhood and were particularly interested in the possibility of restoring species to places where they had become extinct. They quickly enrolled Robert

M. Warren (✉)
Butterfly Conservation, Manor Yard, East Lulworth, Dorset BH20 5QP, UK
e-mail: mwarren@butterfly-conservation.org

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Fig. 6.1 Sir Peter Scott (centre) with Robert Goodden (left), Lady Scott (right) and Rosemary Goodden (aright) at an early meeting of the British Butterfly Conservation Society at Compton House in Dorset, c. 1970

Goodden and his wife Rosemary, who soon took on the day-to-day running of the Society from their offices at Worldwide Butterflies in Dorset. Robert Goodden (Fig. 6.1) had learnt about rearing butterflies during his time as an apprentice to the famous butterfly enthusiast, L. Hugh Newman, who had pioneered butterfly gardening at the home of Winston Churchill at Chartwell in Kent.

Robert regularly discussed butterflies with television naturalist Peter Scott, son of the famous explorer Scott of the Antarctic, and persuaded him to become the Society's first President. This was a substantial coup for the Society because Peter Scott was then the face of natural history on television and his appointment as President gave the new Society real credibility.

During its early years, the Society was very much an information-sharing organisation, but the members were galvanised by reports of the possible extinction of the Large Blue in 1970. In 1972, they started the Habitat Survey Scheme, which began the Society's long history of using volunteers to gather vital information on the status of butterflies and their habitats. However, by 1974 they were still a very small Society and just 20 people attended the AGM in London, to hear that they were still struggling to balance the books, with an income of £501 and expenditure of £643.

6.3 Making a Stand for Butterflies

During the 1970s, the Society began fighting to save key habitats and successfully stopped an old railway cutting in Warwickshire being used as a refuse tipping site, and blocked a proposed glue factory in Leicestershire. In 1973, the Society listed six species as endangered: Large Blue *Phengaris arion*, Large Tortoiseshell *Nymphalis polychloros*, Black Hairstreak *Satyrium pruni*, Chequered Skipper *Carterocephalus palaemon*, Silver-spotted Skipper *Hesperia comma* and Large Heath *Coenonympha tullia* (southern race). Membership grew steadily and by the Society's tenth anniversary in 1978 had reached around 1,000 members. In the following year, 1979, the Large Blue became extinct despite the efforts of a young scientist, Dr Jeremy Thomas, then based at the Institute of Terrestrial Ecology at Monks Wood, Cambridgeshire. Thomas reported to the Society that although a lot of work had been done to save the species, much of it had been irrelevant and harmful. He and others influenced the Society to ensure a sound scientific basis in future conservation efforts.

In 1979, the Society established its first local Branch in the West Midlands. This network grew quickly and there are now 31 Branches throughout the UK, each co-ordinating efforts in its area, publishing local newsletters and running websites. These Branches have been the grassroots powerhouse of the Society and brought together amateur enthusiasts who often had immense and detailed knowledge of their local areas, and who had the passion to take local action.

Wider interest in butterflies increased over the years and 1981 was declared Year of the Butterfly. The aim was to raise awareness of butterflies and the threats they faced. A major television programme on butterflies was broadcast by the BBC and the cover story of the mass circulation Radio Times was all about butterfly conservation. A further television programme later that year covered the publication of a series of postage stamps, based on paintings of four species by Gordon Beningfield. In 1982, the importance of butterflies was recognised in legislation with the Wildlife and Countryside Act, which gave full protection to the Large Blue, Swallowtail *Papilio machaon*, Heath Fritillary *Melitaea athalia* and Chequered Skipper.

My own involvement with the Society began during the early 1980s when I started working on the Heath Fritillary, which was the next candidate at great risk of following the Large Blue to extinction. In 1983 I was appointed as Butterfly Ecologist for the government's Nature Conservancy Council and joined the Society's Conservation Committee to co-ordinate action. Much of our time was then spent developing a position on the vexed question of re-introductions and in opposing major developments such as the planned M40 motorway which was set to destroy part of Bernwood Forest, a top butterfly site near Oxford. As a result of our efforts, the route was moved so that it only clipped the wood and a compensation area of farmland was bought between the wood and the new road. This was then restored to good butterfly habitat under plans devised by Dr Jeremy Thomas who was then working at the Institute for Terrestrial Ecology in Dorset. The results have been spectacular and decades later the site has been colonised by both the Black and Brown Hairstreak (*S. pruni and Thecla betulae*).

6.4 The First Reserves for Butterflies

The establishment of nature reserves for butterflies has had a long tradition in Britain. One of the first ever nature reserves was established at Wicken Fen by the National Trust in 1899, having been purchased by Lord Charles Rothschild partly to protect an important population of the Swallowtail. In 1910, Lord Rothschild also bequeathed Woodwalton Fen to the newly formed Society for the Promotion of Nature Reserves to protect the habitat of the Large Copper *Lycaena dispar* and in 1920 he bequeathed Meathop Moss to protect important colonies of the Large Heath and Silver-studded Blue *Plebejus argus*.

The British Butterfly Conservation Society acquired its first reserve in 1985, a small site at Little Breach in the Blackdown Hills. The following year, it acquired a more substantial reserve at Monkwood with the Worcestershire Trust for Nature Conservation. The site was famous for the Wood White *Leptidea sinapis* and other local woodland species. This started a process of steady acquisition to protect important sites and demonstrate best management practice (see below).

6.5 The Professional Era of Paid Staff

By the time the Society celebrated its 20th anniversary in 1988, it had an annual turnover of just £14,700, no staff and around 2,500 members. However, the previous year the Chairman, John Tatham, had warned the main organising committee that the need for at least one member of staff may arise in the not too distant future to cope with the growing number of Branches and increasing workload. His foresight heralded a period of rapid growth and in the next 20 years turnover increased 170 times to over £2.6 million, membership increased to 13,000 and the number of staff grew from zero to over 55.

The transformation began when Dr Harold Hughes took over as Chairman in 1990 and, with Vice-chairman Dr Ian Small, drafted the charity's first development plan which aimed for one thing: to triple membership. They realised that paid staff would be essential to implement this plan and secured some funding from the Nature Conservancy Council to employ a Director. In 1991, they appointed Andrew Phillips as the first staff member, a management consultant who had a passion for butterflies and tremendous energy to drive the plan forward.

Later in 1991, the plan was crystalised as Operation Butterfly, which was launched with the help of PR staff at Janssen Pharmaceuticals. To make our message easier to sell, the Society's name was abbreviated simply to 'Butterfly Conservation' and a marketing company, Young and Rubicam, redesigned the logo to give the charity a new look. The body of the symbolic butterfly was meant to look like a tree, to reflect a dominant public perception at the time that conservation meant trees. Although not everyone liked the new look, it has served the organisation well for over 20 years.

The next significant event occurred in 1992, when the Vincent Wildlife Trust gave an endowment of £1 million to provide a regular income for Butterfly Conservation in perpetuity. The sum would have to be invested to maintain its value, but the interest could be used to implement the charity's plans. This extremely generous and far-sighted move was the idea of the Rt Hon Vincent Weir, an ardent conservationist who saw that most small wildlife charities struggled to develop through a lack of core funding. It was the spring-board that revolutionised Butterfly Conservation and enabled the transformation to become a reality. His largesse also extended to other small charities including Plantlife, the Bat Conservation Trust and the Herpetological Conservation Trust, who remain strong allies today in our fight to save wildlife.

6.6 Membership Soars

The charity's transformation was given another major boost during 1992 when BP provided £50,000 for an advertising campaign. Numerous adverts were placed in newspapers and magazines, which led to a phenomenal increase in membership from 3,000 to 10,000 in the space of just 3 years. This growth required taking on more staff, both to service the membership and build a financial system that could cope with the growing budget. A Head Office was established near to Andrew's home in the Essex village of Dedham, and new staff were appointed to manage the growing membership and finances.

6.7 Building the Scientific Base

With the new income from the endowment, Butterfly Conservation was able to expand its conservation activities. The first step was to employ a Conservation Officer and, in May 1993, I was privileged to be appointed as the first conservation member of staff. However, funds were still tight and I worked from the living room of my home in North Dorset. I even had to buy my own computer, an old Amstrad which printed on an extremely noisy 'daisy-wheel' printer. This took several minutes to chug through a single page but saved the expense of a typist!

Soon after I joined, Andrew Phillips resigned to resume his business career and leaving me to pick up much of his work. I was quickly inundated and requests for advice poured in. In the first few months alone, I had over 50 requests to give talks and could easily have done nothing else. However, I was committed to achieve conservation on the ground and quickly realised it was a bigger job than one person could handle. Thanks to some extra funding, we managed to employ a part-time assistant, Jan Higgins, and within a year I was thankfully joined by Paul Kirkland as Conservation Assistant. There were now three people working in my living room and my wife's patience was running thin, so we decided to move out and establish a Conservation Office. We were extremely lucky to find ideal premises in the village of East Lulworth, within a field station of Bournemouth University. Not only did the office have good facilities, it was close to wonderful butterfly habitats along the Dorset coast including Lulworth Cove, where the Lulworth Skipper *Thymelicus acteon* was first discovered.

The scientific base of the Society leapt forward in 1993 with the start of the 'Butterflies for the New Millennium' recording project, the brainchild of Jim Asher who had served for years on the Conservation Committee. Jim designed his own software, known as *Levana* (the Latin name for the European Map Butterfly), to allow anyone to enter records in a standard way, and submit them for easy collation. The computer age had truly begun and allowed us to start assembling the biggest dataset on butterflies anywhere in the world, currently with nearly 8 million records. By 1998 the project had really taken off and a dedicated Project Officer was employed in the person of Richard Fox, who has since gained an international reputation from his research findings based on this and the subsequent Moths Count project (see below).

The next big scientific project was to amalgamate the data from the numerous butterfly transects run by Branches. The Butterfly Monitoring Scheme had been run by the Institute for Terrestrial Ecology since 1976 but was limited by finance and logistics to around 120 sites. However, the methodology proved so popular that by the mid 1990s several hundred more transects were being walked by volunteers around the UK, often co-ordinated by Butterfly Conservation Branches. We realised that if the results were combined they would build a unique and powerful database to detect trends to inform conservation and assess the newly recognised phenomenon of climate change. This complex task was achieved by Dr Tom Brereton who was employed as Monitoring Ecologist in 1999 with funding from the Ministry for Agriculture's R&D programme. The Ministry took some convincing that volunteers could gather scientifically robust data but we eventually convinced them that volunteers were good naturalists and this was not only an extremely cost-effective way of gathering data from hundreds of sites but it was probably the only way to obtain such data.

Thanks to Tom's efforts we were able to combine forces with Dr David Roy at the Centre for Ecology and Hydrology and establish the combined UK Butterfly Monitoring Scheme. This now covers well over 1,000 sites and in 2007 achieved our goal of generating an annual butterfly index that has been adopted as a key government environmental indicator. Data from the scheme has been used to publish hundreds of scientific papers on topics ranging from species ecology and habitat fragmentation to climate change. The data and analyses have also been used to understand and improve habitat management for biodiversity as well as assess the effectiveness of nature designations such as Sites of Special Scientific Interest and agri-environment schemes. Transect walkers have already travelled the equivalent distance of walking to the moon, and now we are asking them to walk back again to help us understand changes in this key group of insects.

6.8 Taking Action for Butterflies and Moths

In 1992, Governments from around the world met in Rio de Janeiro to discuss the crisis in global biodiversity loss. They signed the landmark Convention on Biological Diversity (CBD) which aimed to ensure the conservation and sustainable use of the world's biodiversity. In order to press the UK government to take action and ensure that the convention did not just gather dust on the shelf, a few leading voluntary conservation groups came together to form Biodiversity Challenge. This included large and well known groups such as the Royal Society for the Protection of Birds (RSPB), the Wildlife Trusts, Friends of the Earth and the World Wildlife Fund, but also two smaller groups, Plantlife and Butterfly Conservation, to ensure good taxonomic coverage. The group's challenge to Government came in the form of a detailed programme of action that we felt was needed to ensure the conservation of threatened habitats and species. Specifically, we drew up a series of action plans, which had clearly defined targets, objectives and actions, with identified lead organisations.

Butterfly Conservation's contribution to the drafting of the plans also involved Alan Stubbs, who was then acting as a volunteer on our Conservation Committee. As the former chief entomologist with the Nature Conservancy Council, he was able to contribute plans on a wide range of insects, ensuring that this important group was given major recognition. The bulk of our proposals were quickly adopted by Government and published as the UK Biodiversity Action Plan (UKBAP) and a subsequent series of Species and Habitat Action Plan documents. Thanks to our input, butterflies and moths also featured heavily in the plan and over 64 Lepidoptera (12% of all listed species) were listed as Priority Species.

The UKBAP acted as a springboard for conservation as it established clearly recognised national and regional priorities for action. It was also a pivotal plan because it recognised the need for concerted action for threatened species as well as habitats, and intrinsically recognised that species cannot be conserved by a purely habitat based approach. This was a major development because through the 1970s and 1980s, the predominant thinking was that if one looked after the habitats the species would follow. However, information on butterflies clearly showed that this approach was not working and many famous nature reserves (such as Monks Wood in Cambridgeshire) and designated sites continued to lose species at an alarming rate. The reality is that we need both approaches for an effective strategy to conserve biodiversity.

To ensure that the Government's Species Action Plans were implemented effectively, various groups were appointed by them as Lead Partner. Butterfly Conservation was proud to be appointed as Lead Partner for all but one of the 64 Lepidoptera species. We devised a major umbrella project known as 'Action for Butterflies', which aimed to draw up and implement action plans for our 25 most threatened butterflies (Fig. 6.2), as well as Regional Action Plans to guide the work of the Branches. Thanks to a grant from the Nature Conservancy Council in 1995, we were able to employ Dr Linda Barnett as the first Species Action Co-ordinator, to be followed in 1996 by Dr Nigel Bourn when Linda moved overseas. Nigel has since become Director of Conservation, building and leading a team of over 20 conservation staff.

Our reputation was given a major boost in 1997 when ICI became the first Corporate Species Champions, through sponsoring over £115,000 to implement plans for the Large Blue and Pearl-bordered Fritillary *Boloria euphrosyne*. The initiative was felt to be so important by government that the launch was attended by the then Minister for the Environment, John Gummer MP.

Fig. 6.2 BC's Regional Action Plans were launched in 2000 at the House of Commons with (from left to right) Tony McWalter MP, the Environment Minister Michael Meacher, Sir David Attenborough, Stephen Jeffcoate and Martin Warren

6.9 Woodland Campaign

One of the most pressing issues facing butterflies was the rapid decline of woodland species, many of which had become highly threatened. To raise awareness of this problem, we started a Woodland Campaign in 1995 which was generously funded by the car manufacturers Land Rover. We produced a colour information pack and fact-sheets and embarked on a series of visits to key woodland sites. Here we met wood-land owners to give advice and impress on them the importance of active woodland management. We publicised the visits through press releases to the media and achieved widespread coverage including several TV and radio interviews and hundreds of press articles. Although the Campaign achieved its main objective of raising awareness, the neglect of woodlands remains a serious problem due to the economic constraints and lack of suitable markets. It continues to be an important theme in our current work.

6.10 Moths Move Up the Agenda

Up until the 1990s, the focus of Butterfly Conservation had been clearly on the conservation of butterflies and comparatively little attention was paid to moths, even though they were a major part of our charter. However, this changed rapidly in the early 1990s through the efforts of Dr Paul Waring and Dr Linda Barnett who evan-gelised the wonders of moths to our Branches and began appointing Branch Moth

Officers. The recognition of over 50 moths within the UK Biodiversity Action Plan gave a clear focus to our work and enabled us to approach the Nature Conservancy Council for a grant to start a major new ‘Action for Moths’ project. In 1999, two Moth Officers were appointed: Mark Parsons (now our Head of Moth Conservation) and Dave Green. The enthusiasm and high reputation of Mark and Dave galvanised our moth work and gave us the expertise to get to grips with the complexities of moth conservation and develop other moth projects such as Moths Count and the National Moth Recording Scheme. We have since developed major projects on moths and they are now integral to every aspect of our work.

6.11 Branches and Reserves Grow

Although over 15 Branches existed by 1988, new ones continued to be formed to become a full UK wide network of 31 Branches over the next decade. The depth of Branch work and activities continued to grow apace, with major new reserves being purchased at Prestbury Hill (Gloucestershire), Catfield Fen (Norfolk), Grafton Wood (Worcestershire), and Caeau Ffos Fach (Carmarthenshire). In Hampshire, the reserve at Magdalen Hill Down was greatly extended by converting 30 ha of adjacent arable fields back to flower-rich grassland.

Then, in 2007, we had the opportunity for our biggest ever reserve project. After a 10 year campaign by West Midlands Branch, we were finally able to purchase a large part of Prees Heath, thereby safeguarding the last remaining colony of the Silver-studded Blue in the Midlands. Thanks to the efforts of Head of Reserves, John Davis, we were able to secure £573,000, our largest ever grant for reserves, to buy the site and begin restoring large areas of heathland from surrounding arable land.

Further reserves were added over the years so that by 2010, we manage 34 reserves covering over 700 ha of prime butterfly and moth habitat. These include top Lepidoptera sites such as Catfield Fen (a designated National Nature Reserve that supports an important population of the Swallowtail) and Loch Arkaig in Scotland, habitat for the Chequered Skipper and Pearl-bordered Fritillary as well as the Argent and Sable moth *Rheumaptera hastata*.

The expertise and time of Butterfly Conservation volunteers had been the bedrock of the charity, but the new recording schemes and Regional Action Plans lifted this onto a new level. The number of Branch field trips and events grew to their current level of over 700 per year. An audit of volunteers in 2010 showed that they contribute over £9 million pounds of effort every year, equivalent to 655 full-time staff.

6.12 The Challenge of Devolution in the UK

By the late 1990s, devolution was presenting new challenges to Butterfly Conservation. In 1991, the Nature Conservancy Council had been split (ostensibly to reduce its power and influence) into separate bodies in England, Scotland, Wales and Northern Ireland. By 1998, new government administrations were established in these four countries and conservation was fully devolved to new executives. It became increasingly clear that it was no longer credible to organise conservation in all four UK countries from our existing offices in southern England.

So the decision was taken to start an office in Scotland in 1996, and appoint Paul Kirkland first as Conservation Officer (north) and later as Director for Scotland. This was soon followed by the establishment of offices in Wales and Northern Ireland, each funded with help from the respective conservation agencies. Later, in 2002, the first of several Regional Officers was appointed in England to work with Branches within the new English government regions on the implementation of our Regional Action Plans. These national and regional offices were able to tap into new funding streams within the devolved countries and enabled us to expand our activities substantially throughout the UK, turning a major challenge into an opportunity.

6.13 Head Office on the Move

After the sad and untimely death of our President, Gordon Beningfield, in 1998, we were fortunate when Sir David Attenborough agreed to succeed him in 1999. By then the operation of Butterfly Conservation had become so large (with 22 staff and a substantial turnover) that the appointment of a Chief Executive had become essential. Under a new Chairman, Stephen Jeffcoate, the National Executive Committee was to become a more strategic body and was renamed as Council. It was also becoming clear that having split offices in Dedham (with 4 staff) and a Conservation Office in Lulworth (with over 15 staff) was inefficient and would inhibit the next stage of growth.

Late in 1999, David Bridges was appointed as the charity's first Chief Executive. He set about the unenviable task of combining the two offices and taking the tough decision to close the Dedham Office and open a new Head Office in East Lulworth. We were very fortunate because the Lulworth Estate happened to be converting their old builder's yard into offices close to our existing Conservation Office. The new offices proved popular with staff and visitors alike and were opened on a marvellous sunny day in 2001 by Alan Titchmarsh, a TV gardening celebrity, who had recently agreed to become a Vice President (Fig. 6.3). The event was also attended by local MP Jim Knight, who became a useful contact when he later became Biodiversity Minister.

6.14 Landscape Scale Conservation and the Need to Think Big

Through the 1990s, there was mounting evidence that the crisis of habitat loss during the twentieth century had presented a serious new problem to butterflies, that of habitat fragmentation. Most habitats where butterflies and moths survived in the UK

Fig. 6.3 Alan Titchmarsh (right), a new Vice President, opens the new Head Office in Lulworth in 2001 with Stephen Jeffcoate looking on

were small remnants of formerly widespread habitats. Through the work of Ilkka Hanski, Chris Thomas and others, we became increasingly aware that chances of population extinction was far greater on small patches of land and that networks of interconnected habitat were essential to ensure their long term survival. Moreover, climate change was predicted to exacerbate this problem as species may have to move to survive. In short, we had to ‘think big’ if we were to succeed in saving butterflies and moths from extinction.

To address the problem of conserving species in a fragmented landscape, several pioneering projects were developed by Dr Nigel Bourn and his species team, and aimed at conserving networks of habitat within extensive landscapes. This clearly requires far more effort and resources than small scale conservation, but was vital if we were to be successful. We therefore began raising funds for major projects in key landscapes for Lepidoptera. This approach is now a fundamental aspect of our conservation strategy and we are currently involved in over 70 landscape scale projects around the UK (Fig. 6.4). Each project involves a large partnership of volunteers, landowners and organisations working together to a common aim. In some of the landscapes, Butterfly Conservation is a major player with a full-time officer, while in others we have a more advisory role and partner organisations take the lead.

The first landscape scale projects with full-time officers were started in 2004, simultaneously the Re-connecting the Culm and the Two Moors project, both in south-west England. The former focussed on a highly fragmented grassland

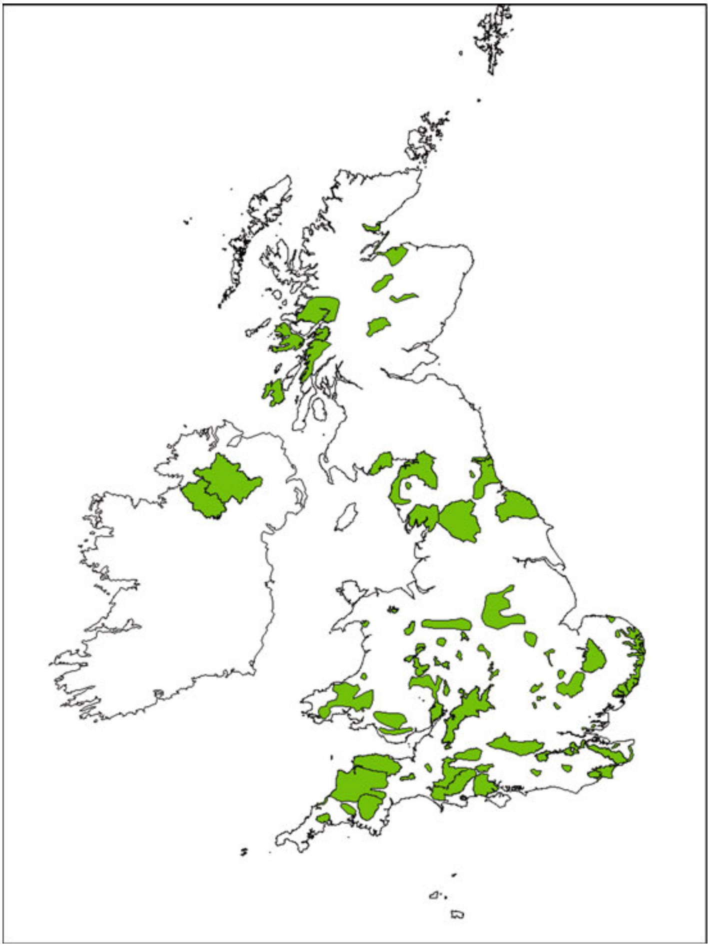

Fig. 6.4 Map showing the 76 landscapes targeted by Butterfly Conservation to conserve threatened species

landscape which was a stronghold of the Marsh Fritillary *Euphydryas aurinia* and several rare moths, while the latter focussed on this species as well as the High Brown Fritillary *Argynnis adippe* and Pearl-bordered Fritillaries. The biggest scheme, the South-east woodlands project, has three people working full time giving advice to owners and raising awareness amongst the forestry community of the need for active management. It has raised over £0.5 million for direct woodland management such as widening rides and re-instating coppicing. It also aims to develop markets for wood-fuel to ensure sustainable management in the long term.

The results are beginning to pay off and several threatened species are beginning to recover after decades of decline.

6.15 Funding Major Projects

In order to develop and sustain these and other major projects, we needed to raise substantial funds every year. We are fortunate to have a wide range of possible funding sources in the UK, ranging from Government grants and the Lottery to grant making trusts and foundations. However, successfully applying for such grants is a complex task as each fund has their own priorities and often labyrinthine rules that have to be satisfied. If we were to expand, it was vital that we employed a skilled fundraiser who could tackle this minefield of paperwork and be successful.

Luckily a piece of serendipity helped us make this important step. Our Chief Executive, David Bridges decided to move back to his home in 2004 for personal reasons but offered to continue to work as Head of Fundraising, a task that could be done from a home office. I was fortunate to apply successfully for the vacant post and thus had the benefit not only of having David as a mentor in my early years as Chief Executive, but also of retaining his immense skills as a fundraiser. As the years have passed, we have expanded the fundraising team and it now includes two other fundraisers, one concentrating on appeals and individual donations, the other on Trusts. Thanks to their work, and Sam Ellis as Head of Regions, we have been able to expand our landscape scale projects and retain experienced regional and national teams. They are achieving a step-change in practical conservation and beginning to reverse the fortunes of numerous threatened species.

Over the years, we have also raised significant funds from various Corporate partners, as well as from the generosity of individuals. The first major partner was BP who funded a series of adverts for the Society in 1992 worth £50,000. They were followed by Land Rover in 1993–1995 and in 1997 these were eclipsed when we secured £115,000 from the chemical giant ICI. Their price was a high profile launch with the then Environment Minister John Gummer. We have subsequently worked with the insurance firm NFU Mutual and a series of book publishers who kindly donated royalties. In 2010 we embarked on our biggest partnership with the high street retailer Marks and Spencer, as part of their Plan A programme that aims to make them the greenest retailer in the world by 2015. The partnership involves receiving royalties from the sale of a number of butterfly-related products as well as giving advice on butterfly (and moth) friendly farming to their 10,000 producers and launching the big butterfly count to raise awareness amongst their customers. The partnership was launched by Sir David Attenborough at the Bath and West showground and the interview with him can be viewed on www.plana.marksandspencer/about/partnerships

6.16 Making Moths Count

There have been several attempts to start and run a national recording scheme for larger (macro) moths in the UK, but for one reason or another they had all failed. The task had simply been too large and complex, and funding had never been secure for long enough for any organisation to succeed. However, with the advent of new

Fig. 6.5 Dudley Cheesman, Sir David Attenborough and Maurice Avent (left to right) at the Royal Entomological Society, at the launch of the State of Britain's larger Moths Report, 2006. The Report showed for the first time the depth of the crisis facing moths, with two-thirds of common species declining. The report provided a spring board for the Society's largest ever project, Moths Count

identification guides, moth recording was becoming increasingly popular and it was becoming increasingly important that we had better information on a wider range of species, many of which we knew were changing their distributions rapidly.

We therefore embarked on our biggest ever project, to develop a National Moth Recording Scheme (Fig. 6.5) and collate the millions of records we knew were out there in the computers and notebooks of local recorders. After years of preparation, we applied to the Heritage Lottery Fund for a major grant to employ a team of people who could perform the task. The total cost of the project, which we called Moths Count, was over £1 million to which the Lottery contributed £806,000. The remainder came from contributions from Butterfly Conservation, the statutory conservation agencies and individual donors and companies.

The Moths Count project has been enormously successful and by 2010 had gathered over 11 million records from over 3,000 recorders, giving complete UK coverage of over 900 macro-moth species. These are available online via the Moths Count website. It has also run over 200 events, attended by over 3,500 people, and produced a range of colourful leaflets. The success of the project has been partly down to the dedicated staff on the project, led by Richard Fox, but also because of the enormous voluntary work by the 120 vice county recorders who co-ordinate and validate records from their areas. Without their help, it would be impossible to run such a large scheme with such a small central team. The dataset now assembled provides a unique resource for research and to identify conservation priorities. It will also be used to update a State of Britain's Moths report in 2012 to further raise awareness of the importance of moths and the need for their conservation.

Fig. 6.6 Maurice Avent, Sir David Attenborough and Martin Warren (left to right) outside the Natural History Museum, London, at the launch of Save Our Butterflies Week, July 2008

6.17 Publicising Butterflies and Moths

Raising awareness of butterflies and moths has been a crucial part of Butterfly Conservation's strategy for several decades (Fig. 6.6), both to influence the general public as well as land owners and policy makers. In the 1970s, coverage was sporadic, although major stories covered the Society and its work, often orchestrated by the Chairman, John Tatham, who operated from his home in Quorn in Leicestershire. Coverage was pushed to a higher level during the early 1990s, when the Society employed Gary Roberts as a part-time consultant to issue press releases and organise high profile events. When I started working for Butterfly Conservation in 1993, Gary and I embarked on a PR tour of Britain in a brand new Range Rover, courtesy of our sponsors, Land Rover. 'Butterfly Check' aimed to highlight the plight of 25 of our most threatened species. We followed this with the Woodlands Campaign over the following 3 years.

We employed our first full time Publicity Officer, Carmel Mallinson, in 2002 to begin issuing regular press releases and to handle the increasing number of media inquiries. In another piece of serendipity, when Carmel went on maternity leave in 2005 we were very fortunate to lure Lester Cowling out of retirement to fill the post. With a lifetime's experience in press and radio, Lester pushed our publicity onto an even higher level with his superbly crafted press releases, which turned even the dullest stories into blockbusters. Lester continued with us when Carmel decided not to return from maternity leave and led a growing Publicity team which now consists of 2.5 staff.

In 2009, we finally let Lester reduce his hours to become editor of 'Butterfly', our in house magazine for members. He was replaced as senior Publicity Officer by Louise Keeling who has continued to manage an enormous workload and myriad press inquiries. The massive change that these colleagues have achieved is admirably demonstrated by our archive of press clippings. When I started it took 2 years to fill a book, now we need 3–4 books per year!

6.18 International Symposia

Butterfly Conservation's first International Symposium was organised by Andrew Pullin and held at Keele University in 1993. They have since been held at 3 yearly intervals and have become significant events on the Lepidoptera researcher's calendar. The Symposia have been a great meeting place for exchanging ideas and forging collaborations. The last Symposium was held in Reading in March 2010 on the topical theme of 2010 and beyond for Lepidoptera. Over 300 people attended, from over 20 countries. The Symposium was opened by Sir David Attenborough who gave a rousing speech in which he said that halting biodiversity loss was the coming decade's great challenge, on a par with getting a man on the moon in the 1960s. The Symposia have led to two books based on the proceedings, the first published by Chapman and Hall entitled 'The Ecology and Conservation of Butterflies' (Pullin 1995), the second from our most recent Symposium published by Springer entitled 'Lepidoptera Conservation a Changing World' (Dover et al. 2011).

6.19 Butterfly Conservation Europe

During the 1990s, we had become aware that the situation for butterflies and moths was just as dire in mainland Europe as it was in Britain and that many conservationists were looking to Butterfly Conservation to take a lead. The International Symposia had underlined this fact and many delegates urged BC to take more of a lead in Europe. So, in 2004, after some detailed discussions with Dutch Butterfly Conservation and other European colleagues, it was decided to form a separate umbrella organisation, Butterfly Conservation Europe. We decided to constitute this as a non-profit making organisation (Stichting) in the Netherlands as this required the minimum bureaucracy (and a lot less than running a UK charity!).

The founding Board members were myself, Theo Verstrael (De Vlinderstichting, Netherlands), Josef Settele (UFZ research station, Germany) and Dirk Maes (Institute for Nature Conservation, Belgium). We were joined by advisors Chris van Swaay and Irma Wynhof. We signed the documents in Wageningen on 16th

Fig. 6.7 The formal signing of BC Europe: Martin Warren and Josef Settele (*left to right*)

November 2004 (Fig. 6.7) and celebrated in the De Wereld Hotel where the peace treaty was signed at the end of the Second World War. A few years later the Board was completed with Martina Sasic (Croatia), Rudi Verovnik (Slovenia) and Miguel Munguira (Spain). Although the new organisation was run initially on a voluntary basis, we were immediately fortunate to have an offer of help from Sue Collins who had until recently been Policy Director with English Nature. She had been one of the architects of the EU Biodiversity Action Plan and offered to work with us on a voluntary basis, promoting Lepidoptera and biodiversity in the corridors of the EU in Brussels.

BC Europe aimed to operate with the minimum of bureaucracy and established a set of Operating Principles for any Network Partners who wished to collaborate. The response was extremely positive and we held an Inaugural Meeting in 2007 in Laufen, Germany. Subsequently 34 organisations from 32 countries have joined the network, ranging from well organised Lepidoptera Societies to Research Institutes and small research groups based at Universities or Museums. We have successfully raised funds from the Dutch Government to conduct Prime Butterfly Area projects in eastern European countries such as Bulgaria and Serbia as well as a major development project in Turkey. We have also published and promoted a European Grassland Butterfly Indicator and Climate Change Indicator, based on the growing network of European butterfly transects that now covers 15 countries. In 2010 we secured our first EU grant to run the organisation, which enabled us to employ three part-time officers to develop and build the network. Future conferences are planned as well as an expansion of the BC Europe website and increased lobbying for better European policies to conserve Lepidoptera and biodiversity.

6.20 The Future

Butterfly Conservation has come a long way in the 42 years since its founders met in a small London flat. The chronology of its development is summarised in Appendix. It now has a turnover of over 3 million pounds, 82% of which is spent on conservation, as well as 58 staff and thousands of active volunteers. This success has been the result of a unique combination of amazing volunteer effort, expert staff, a lot of hard graft, a little serendipity, and a great deal of good will and enthusiasm from a wide range of partners and supporters. During its lifetime, the organisation has made many advances and established butterflies and moths as being worthy of conservation in their own right, but also as being valuable indicators of the health of the environment. Moreover, thanks to its efforts, several species are now beginning to recover after decades of decline and the requirements of many other species are well enough known to design targeted conservation programmes.

However, we are painfully aware that many species continue to decline and we need to redouble our efforts in coming years. In simplistic terms, we just need to scale up our efforts to apply them at a sufficiently large scale and sustain them for long enough to be effective. To this end we are developing a new 10 year strategy; a 2020 vision that aims for another period of major growth to secure the extra resources that are needed to expand and sustain our effort in the long term. Against a backdrop of economic recession and budget deficit, this is an enormous challenge, but we are determined to do all we can to achieve our aim of saving butterflies and moths, as a vital contribution to conserving biodiversity.

Acknowledgements I am grateful to many people who have contributed information to the above account, especially Julian Gibbs, Martyn Davies, Tony Hoare, Harold Hughes, Nigel Bourn and Lester Cowling. I would also like to express my deep thanks to all the volunteers and staff who have helped make Butterfly Conservation a success.

Appendix: Butterfly Conservation Timeline

1968	7th March – British Butterfly Conservation Society (BBCS) registered as a charity, membership £1. Thomas Frankland was appointed as first Chairman
	5th April – Society inaugurated and announced in Observer newspaper
	Sir Peter Scott becomes first President
	First newsheet published 1st October – (2 sides of foolscap paper)
1969	Robert and Rosemary Goodden help run society from their offices at Worldwide Butterflies
1970	Possible extinction of Large Blue in Britain is reported
1971	John Tatham takes over as Chairman
1972	BBCS News goes from A4 to A5 format
	Habitat Survey Scheme started and 25 forms returned

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1973	Six species listed as endangered: Large Tortoiseshell, Black Hairstreak, Chequered Skipper, Silver Spotted Skipper, Large Heath (Southern Race) and Heath Fritillary
1974	AGM in London attended by 20 people Balance Sheet shows income of £501 and expenditure of £643
1977	BBCS News includes first article on climate change and its effects on butterflies Membership reaches 940
1978	Tenth Anniversary Celebration at Worldwide Butterflies
1979	First local group formed in July in West Midlands Membership reaches 1,100 Large Blue becomes extinct in Britain
1980	News contains first black & white photos London Branch formed and other Branches planned
1981	Post Office butterfly stamps painted by Gordon Beningfield issued 13th May First reserve agreements with Forestry Commission on two small areas in Somerset
1982	Wildlife & Countryside Act protects Large Blue, Chequered Skipper, Heath Fritillary and Swallowtail
1984	WWF announces over 20 Butterfly Projects to be funded by Associated Tyre Service
1985	Sir Peter Scott attends AGM
1986	First nature reserve purchased at Monkwood, jointly with Worcestershire Nature Trust First coloured front cover on News
1987	First two booklets produced "Gardening for Butterflies" & "Butterflies of the Southern Chalk Downlands"
1990	Gordon Beningfield becomes President on the death of Sir Peter Scott Andrew Phillips appointed as Director to become first paid member of staff First funding partnership with Inoven (pharmaceutical company) Butterfly Line – phone line of sightings started by Nick Bowles
1991	Harold Hughes takes over as chairman New logo introduced Membership reaches 4,000
1992	Society receives £1 million endowment from Vincent Wildlife Trust BP sponsors Education Pack and series of adverts First colour photos in magazine Membership reaches 6,000
1993	Head Office established in Shakespeare House, Dedham, Essex Staff are Debra Scullion, Karen Corley, Ken Ulrich, Liz Bywater Andrew Phillips resigns as Director Dr Martin Warren appointed as first Conservation Officer First International Symposium held at Keele Membership reaches 9,000
1994	New Life for Old Woods campaign sponsored by Land Rover First A4 issue of News
1995	First year of Butterflies for the New Millennium recording project, run by Jim Asher Action for Butterflies started, funded by Nature Conservancy Council, Dr Nigel Bourn appointed

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1996	Coppice for Butterflies Challenge grant scheme announced by Forestry Commission
1997	BC Scotland Office opened in Edinburgh
	Biodiversity partnership with ICI to save Large Blue and Pearl-bordered Fritillary
	Second International Symposium at Warwick
1998	Butterfly Conservation garden at Chelsea Flower Show wins gold award
1999	Sir David Attenborough becomes President after death of Gordon Beningfield
	Stephen Jeffcoate takes over as Chairman and David Bridges appointed first Chief Executive
	Regional Action Plans launched at House of Commons with Michael Meacher MP
	Action for Moths project started with two Moth Conservation Officers
2000	Third International Symposium held at Oxford
	First annual National Moth Night
	Head Office moved to Manor Yard, Wareham, Dorset. Julie Williams, Georgie Laing and others appointed to Finance Team
2001	Head Office opened by Alan Titchmarsh on 27th September
	Millennium Atlas of Butterflies in Britain and Ireland published
	First Regional Officer, Dr Sam Ellis, appointed in England
2003	Dudley Cheesman takes over as Chairman and Dr Martin Warren as Chief Executive
	Fourth International Symposium held in Lancaster
2004	First landscape scale projects started in south-west England
	Butterfly Conservation Europe formed as an umbrella body to co-ordinate action across the continent
	Prime Butterfly Areas of Europe published
2005	Fifth International Symposium held in Southampton, attended by over 300 people
	£573K grant awarded to acquire Prees Heath, Shropshire
2006	State of Butterflies in Britain and Ireland published
	Re-introduced Large Blues reach 10,000 adults on 20 sites
	Inaugural meeting of BC Europe held in Laufen, attended by 50 delegates from over 30 countries
2007	Moths Count launched with £820,000 grant from Lottery
	Butterflies adopted as Biodiversity Indicators by UK government
2008	40th anniversary celebrations held, led by Sir David Attenborough
	40th appeal raises over £110,000
	Maurice Avent takes over as Chairman
2009	Distribution maps for macro-moths available for the first time on Moths Count website
	Match Pot appeal raises c. £100,000 to develop landscape scale projects
2010	Fifth International Symposium held at Reading University attended by over 300 delegates
	Membership reaches c. 15,000
	Major partnership launched with high street retailer Marks and Spencer
	10,000 people participate in the big butterfly count in last week of July
	First atlas published of over 900 UK macro-moths
	New Red List of European butterflies published by IUCN and BC Europe

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Part II
North American Developments

Chapter 7
The Origins and History of Insect Conservation in the United States

Robert Michael Pyle

The indigenous insects of North America did not co-evolve with extensive agriculture, as the British fauna has done ever since late Pleistocene glaciation (New et al. 1995). Native American land use, such as burning and garden cultivation, moulded habitats to some extent, as did the impact of the Pleistocene megafauna, mostly extinct within the past 10,000 years. But the imposition of European-style land use – chiefly the cow and the plough, but also the sheep and the goat, the steel axe, and dense occupation – was new to the continent. Its entomofauna doubtless began to change in response to European colonisation from the sixteenth century in California and the Southwest, and from the seventeenth century on the East Coast. Westward movement, extensive 'sodbusting', industrial expansion during the eighteenth and nineteenth centuries, and rapid human population growth in the twentieth and twenty-first centuries, have driven numerous species range contractions and local extinctions (Ehrlich and Ehrlich 1981).

In his landmark book *The Population Bomb*, Paul R. Ehrlich (1968) forecast grave ecological effects from the rapidly growing human populace. Since then, the United States population has grown from about 200 million to over 310 million people. Ehrlich's first book (with Anne H. Ehrlich in 1961) had been the pioneer field guide and key, *How to Know the Butterflies*. Combining these two areas of his interest exemplifies Ehrlich's Impact formula, or IPAT: '$\mathbf{I=P\times A\times T}$' (where I = Environmental Impact, P = Population, A = Affluence, T = Technology), amounting in practical terms to *insects at risk*.

The modern movement to protect American insects at risk got going just about the same time as *The Population Bomb* rolled out. Expressions of concern had occurred much earlier, however, not long after the much-remarked extinction of the English Large Copper butterfly (*Lycaena dispar dispar*) from the draining of the Fens, the great marshes of East Anglia, in the mid-nineteenth century (Duffey 1968). The earliest published notes and exhortations of insect losses in North America

R.M. Pyle (✉)
Swede Park, 369 Loop Road, Gray's River, WA 98621-9702, USA
e-mail: tlpyle@willapabay.org

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Fig. 7.1 Specimens of the extinct Xerces Blue in Yale Peabody Museum (Photo: C.L. Remington)

appeared not much later. Not surprisingly, they pertain to butterflies, usually the first group of insects to be noticed for their presence and lamented for their absence, in any given setting.

San Francisco lepidopterist Herman Behr (1875) wrote to his friend Herman Strecker in Chicago: '*Glaucopsyche xerces* [the Xerces Blue, Fig. 7.1] is now extinct as regards the neighborhood of San Francisco. The locality where it used to be found is converted into building lots, and between German chickens and Irish hogs no insect can exist besides louse and flea.' Meanwhile, on the opposite coast, A. R. Grote (1876) expressed concern for the famous White Mountain butterfly (*Oeneis melissa semidea*) on Mt. Washington in New Hampshire. 'What time, on Bigelow's Lawn,' he wrote, 'I see the ill-advised collector, net in hand, swooping down on this devoted colony, of ancient lineage and more than Puritan affiliation, I wonder if, before it is too late, there will not be a law passed to protect the butterflies from the cupidity of their pursuers – I commend this colony to the protection of all good citizens of the state of New Hampshire.' It is extremely doubtful that collectors could actually threaten this elusive butterfly of difficult terrain. Nevertheless, Grote's plaint must be considered, along with Behr's nearly simultaneous lamentation for the Xerces blue, as echoes of the beginning of insect conservation awareness in North America.

Perhaps the first noted insect extinction in North America was also the strangest. The Rocky Mountain locust (*Melanoplus spretus*) was the pioneers' most challenging insect competitor, producing vast swarms across the western temperate half of the continent. One swarming event in the 1870s was estimated to cover almost 200,000 square miles, containing at least 12.5 trillion insects with a total weight of 27.5 million tons (Ryckman, 1999). But the species was apparently never seen alive after 1902, arguably a victim of the same agricultural practices it so threatened, to which it became vulnerable during non-swarming periods (Lockwood 2001, 2004). The unlooked-for extinction of the Rocky Mountain locust made it clear that human practices could indeed extirpate insects: if this one, of all kinds, then why not any other?

By 1933, some American entomologists had become sufficiently aware of potential impacts to hold a symposium entitled ‘The influence of civilization on the insect fauna of North America’ at the annual meeting of the Entomological Society of America (ESA). The participants attended chiefly to economic implications, but expressed some concern for ‘rare and unusual insects’ which may have become extinct or depleted due to the effects of industrialisation, cultivation, and other processes. They prescribed no remedial action other than abating pollution in the habitats of certain aquatic insects.

A remarkable and precocious statement emerged from ESA’s meeting 3 years later, in the form of the annual public address, delivered by the organisation’s former, and first female, president. Well known as both an entomologist and nature writer, Edith M. Patch titled her talk ‘Without Benefit of Insects’ (Patch 1936). Decades before Rachel Carson, Patch tolled an alarum about pesticides, and pled that ‘in the large economy of nature, insects are beneficial’ (a phrase she attributed to her mentor, O.W. Oestland, in 1901). ‘Are these and many other blessings bestowed by the grace of hexapods assured to mankind forever and ever, amen?’ she asked.

Patch further quoted Oestland: ‘If the time ever comes when insects are fought to the extent recommended by economic entomologists there will be in consequence the greatest of economic disasters – due to the scarcity of insects.’ Patch felt he might be right, and she was apparently not alone. She wrote, ‘One hears disquieted and perhaps disquieting murmurs here and there.’ She quoted ‘an officer of an electric company’ who, when petitioned to construct UV traps for killing insect pests, wrote this: ‘We have hesitated so far because we were not entirely sure of the economic soundness of such wholesale killing, believing that not only the undesirables might be killed, but also there might be a wholesale slaughter of the innocent.’

Edith Patch also quoted the late Charles Johnson of the Boston Museum Society of Natural History, who had told her, ‘I have to come to Maine to get the larger Lepidoptera now. No use looking for them in Massachussetts since the general spraying for gipsy and browntail caterpillars.’ And she asked, ‘is the fate of certain native insects an affair for *museum regrets* only? Is not the reduction in native pollinators already influencing agricultural practices?’ Patch then went on with a detailed discussion of native pollinator and honeybee declines and concerns that presciently anticipated Buchman and Nabhan (1996) and even Colony Collapse Disorder. Imagining a scenario in the year 2000, she wrote with almost eerie timing, ‘For several seasons…there have been serious losses under alarming conditions, due in part…to an over-crowded population of honeybees in many districts; bee diseases…have been on the increase.’

Patch’s address quoted several other distinguished entomologists whom she considered ‘champions’ of insects – ‘their voices heard now and then – whether heeded or not!' These included A. L. Melander of Washington State University, Frank E. Lutz of the American Museum of Natural History, Gayle Pickwell, and the dipterist C. H. Curran, each of whom spoke up for the value of insects and the concern they felt on their behalf because of 'the insect war'. Finally, and delightfully, Patch indulged in 'a few imaginary possibilities' for the year 2000. First, she anticipated the rise of insect-plant coevolutionary studies by positing a 'Phyto-Entomological Society of America.' Bumblebee and hawkmoth preserves would be established, and growers of tomatoes, potatoes, and tobacco enjoined to grow extra crops for the sphinx larvae. The government would 'secure and set aside all available waste land, to be maintained under wilderness conditions as bird and insect preserves. Further, the President of the United States, in order to provide suitable conditions for pollinators, proclaims government reservations in rural areas throughout the country to be maintained as insect gardens under the direction of government entomologists. Milkweed would be grown for the larvae of monarch butterflies, umbelliferous plants for black swallowtails, and so on…no caterpillars are to be killed in these gardens'. Perhaps most dreamily, Edith Patch saw public schools in 2000 having courses on 'INSECTS NECESSARY FOR HUMAN WELFARE, beginning in the first grade in story form and continuing in one and another phase through the grades and high school. All agricultural college students are required to specialize in Economic Entomology, the emphasis being put on *how to save necessary insects while controlling crop pests*.' She concluded her fantasy by stating that 'the fraternity of hive-beekeepers will doubtless continue to fight for the loves of their domestic pollinators,' and asking, 'as for other helpful insects, will defenders of equal zeal rally to their support to the end that mankind may never be without benefit of insects?'

Though her arguments may be called anthropocentric, Patch profoundly anticipated the concerns of later insect conservationists. Scattered overt measures followed. In the mid-1950s, the town of Pacific Grove, California (later styled 'Butterfly Town USA') passed an ordinance protecting the famous winter-roosting Monarch butterflies (*Danaus plexippus*) in its bounds. Steps and missteps to protect and manage their habitat effectively continue to the present, but at least the animals themselves were accorded legal protection (Pyle 1976a, b). The first direct, on-the-ground action for insect conservation of which I am aware in North America was George Rawson's attempt to introduce the Atala Hairstreak (*Eumaeus atala florida*) (Fig. 7.2) from its one known population into a protected site in Everglades National Park (Rawson 1961). This effort was doomed when Hurricane Donna swept through the park with great violence and attendant destruction of vegetation; although the species later regained abundance around Miami on its own.

By the 1960s, following *Silent Spring* (Carson 1962), more voices were being heard. Inspired in part by Carson, and by Wheeler McMillen's reaction to her (*Bugs or People*, 1965), Melville Hatch of the University of Washington wrote 'The cultural value of beetles' (1967). Elaborating the many ways in which beetles enrich life, Hatch noted that 'if beetles are to remain for people to collect and study and enjoy, the human population must not transgress the limits that will continue to make greenbelts and parkland and woodland areas plentiful and unpolluted streamsides and lakesides and bogs available.' He lamented the loss of collecting and

Fig. 7.2 The Atala hairstreak, namesake of the initial Xerces Society journal, *Atala* (Photo: Thea L. Pyle)

teaching sites easily accessible from the university, and proposed the way-ahead-of-its-time idea of establishing beetle gardens.

It was a student of Hatch's, David McCorkle, who was responsible for what may be the first habitat reserve set aside for an American butterfly: The Nature Conservancy established Moxee Bog Preserve in Yakima County, Washington, in 1967, on behalf of the Silver-bordered Fritillary (*Boloria selene*) (Figs. 7.3 and 7.4), at McCorkle's urging (Hendrix 1975).

It was also McCorkle (with this writer) who proposed the original conservation committee of the Lepidopterists' Society at its annual meeting in Corvallis, Oregon, in 1967. At that meeting, I presented a paper on 'Conservation and the Lepidopterist,' concerning the responsibilities of workers in the field to help conserve butterfly and moth habitats (Pyle 1967). In a follow-up paper (Pyle 1968) I proposed a national system of butterfly refuges. Along the same lines, William Sieker (1967) published a paper entitled 'The Importance of Protecting Natural Habitats—NOW' in response to Fred Rindge's 1965 presidential address to the Lepidopterists' Society, 'The importance of collecting – now.' Rindge's contribution was not seen as a conservation paper at the time, but it certainly was, as it drew attention to vanishing biotopes from the standpoint of disappearing biological material, a topic that became commonplace decades later in the writings of E. O. Wilson and others.

The late 1960s and early 1970s, a period of intense social unrest in the United States, witnessed a high degree of environmental activism (Scheffer 1991). It is not surprising that insect conservation mirrored that trend with the launch of the Xerces Society. In 1971–1972, under a Fulbright-Hays Scholarship, I had the opportunity to study with John Heath of the Biological Records Centre and half a dozen other British scientists in the Invertebrate Populations section of Monks

Fig. 7.3 Moxee Bog, Yakima County, Washington, arguably the first butterfly preserve in the U.S. (The Nature Conservancy, circa 1967) (Photo: R.M. Pyle)

Fig. 7.4 The species for which Moxee Bog was designated, the relict Silver-bordered Fritillary, *Boloria selene* (Photo: R.M. Pyle)

Wood Experimental Station in Abbots Ripton, Huntingdonshire, England (Nature Conservancy Council, later Institute for Terrestrial Ecology, see McLean and Key, Chap. 3). John Heath was developing the British Butterfly Recording Scheme, which led to all conservation mapping for butterflies. Eric Duffey was investigating the ecology of reintroducing the Large Copper to Woodwalton Fen from the Continent. Jack Dempster was working on British Swallowtail restoration at Wicken Fen in Cambridgeshire, and Jeremy Thomas was conducting postgraduate research on the autecology of Black and Brown Hairstreaks. Ernie Pollard was launching his now-famous ‘Pollard Walk’ butterfly transect method, and Michael Morris was evaluating the response of leafhoppers to various management regimes in chalk downland. Michael Way was studying verges and Max Hooper, hedgerows. The place was a hotbed of cutting-edge ecology, entomology, and applied biogeography in service to management and restoration of rare insects (and others) and their habitats (Duffey and Morris 1965; Pyle 1976b). But we had no mechanism for technology transfer back to the U.S.A.

Inspired by a lecture on the conservation of the British Large Blue (*Maculinea arion eutyphron*) by Graham Howarth at the British Entomological Society in London, such a mechanism arose. Howarth said, ‘If we lose the Large Blue, let it be a symbol, that we should never lose another British butterfly.’ We had already lost a blue in North America – the Xerces Blue that Behr had lamented to Strecker a hundred years before – which finally became extinct in about 1943 (Downey and Lange 1956). Thus arose the Xerces Society on December 9, 1971: first oriented toward Lepidoptera, then terrestrial arthropods, finally to invertebrate conservation on the whole. The time was right, as an article by Brewer (1972) in *Audubon* magazine suggested, and subsequent events reinforced.

The following summer, Yale University Professor Charles Remington (Fig. 7.5), co-founder of the Lepidopterists’ Society in 1947, staged a symposium on ‘Endangered and Extinct Lepidoptera’ at the Society’s 25th meeting in San Antonio. The Xerces Society had its formal debut at that forum, to helpful questions about its purposes and methods from respected lepidopterists such as Lee D. and Jacqueline Miller, Jerry A. Powell, Lincoln P. Brower, Thomas C. Emmel, and others. This event led the author to doctoral studies with Remington at Yale, which became Xerces’ nursery. The importance of Remington’s encouragement of Xerces in these early years, and of the intellectual and scientific climate at Yale, cannot be overstated. When in Oxford as a Guggenheim Fellow to work with Professor E.B. Ford in 1958–1959, Remington frequented the insect shops and bourses in London and Paris. There he acquired historic specimens that became the foundation for one of his long-time emphases as Curator of Entomology at the Yale Peabody Museum: endangered and extinct insects. This incomparable resource, Remington’s broad experience in biological conservation, and his joint appointments at Yale’s Department of Biology and School of Forestry and Environmental Studies rendered Yale an even more suitable base for the Xerces Society. If Monks Wood was the birthplace and John Heath the midwife, then it has been said that Osborn Memorial Laboratory was the nursery and C.L. Remington the godfather – not only for Xerces, but for the American insect conservation movement in general (Pyle 1995).

Fig. 7.5 Professor of Biology, Charles L. Remington (seated) shows rare butterfly specimens to a fascinated Robert Frost in Osborn Memorial Laboratory, Yale University, circa 1960. The well-known poet was a fellow of Yale's Pierson College and a close observer of natural history (Photo: courtesy of Yale Peabody Museum of Natural History, New Haven, Connecticut)

The first annual Xerces meeting, in New Haven in 1974, featured the Hon. Miriam Rothschild and Professor Alexander B. Klots; the second, at Cornell University, included America's best-known naturalist, Roger Tory Peterson, who was concerned about giant silk moth decline in the wake of Gypsy Moth spraying. Such distinguished support gave substance and credibility to the young organization, such as the presidencies of Sir Peter Scott and Sir David Attenborough have lent the British Butterfly Conservation Society (later, Butterfly Conservation, Chap. 6).

The earliest involvements of the Xerces Society during its first few years, while based at Yale, then Cornell, Berkeley, and the University of Wyoming, included: advising the U. S. Forest Service on the habitat of the recently discovered Sandia Hairstreak *(Callophrys macfarlandi)* in New Mexico; collaborating with the National Park Service to initiate studies on the endemic Schaus' Swallowtail (*Papilio aristodemus ponceanus*) in the Florida Keys; assisting local efforts on behalf of the Albany Pine Bush in New York state, type locality of the rare Karner Blue (*Plebejus samuelis*, formerly known as *Lycaeides melissa samuelis*); and investigating and acting on conservation possibilities for several highly restricted western fritillaries (*Speyeria nokomis, S. adiaste atossa*, and *S. zerene hippolyta*) (Pyle 1976a, b). Meanwhile, various writers were documenting faunal declines around the country (e.g., Shapiro and Shapiro 1973, for Staten Island, New York; Orsak 1977, for Orange County, California). After the passage of the Endangered Species Act (ESA) in 1973, and the appointment of Paul A. Opler as staff specialist in entomology for the Office of Endangered Species, much of Xerces' activity centered on the ESA, (Pyle et al. 1981, and S. H. Black, Chap. 8).

In the mid-1970s, at the instigation of Sir Peter Scott, chair of the Species Survival Commission of IUCN (International Union for Conservation of Nature and Natural Resources), specialist groups were formed for Lepidoptera, Odonata, ants, and cave invertebrates (Pyle 1981). The XVth World Congress of Entomology, held in Washington, D.C. in 1976, occasioned the first meeting of the Lepidoptera Specialist Group. The Group declared the migratory Monarch's winter roosts in Mexico (then only recently located) and in California to be the top priority in world butterfly conservation. A great deal of attention to monarchs and protection of their habitat followed, through Xerces' Monarch Project, Pro Monarca in Mexico, World Wildlife-US, various California groups, and especially the research and conservation efforts of Lincoln P. Brower and colleagues (Brower 1995 and many other papers).

Also owing to Peter Scott, the first IUCN/WWF *Invertebrate Red Data Book* (IRDB) was undertaken by the author and colleagues at the Species Conservation Monitoring Centre in Cambridge, U.K. The ambit of the IRDB was certainly not encyclopaedic, but rather to demonstrate the range of invertebrate animals influenced by the same pressures that also affect vertebrates and plants (Wells et al. 1983). For North America, the book gave greater traction to the migratory monarch system (which Brower and Pyle simultaneously termed a 'threatened phenomenon') and many other invertebrate issues. Aside from Lepidoptera, North American insect taxa treated in the IRDB included three odonates, three periodical cicada species, three beetles, two flies, and the Mount St. Helens grylloblattid. Of these, the periodical cicadas (*Magicicada* spp.) and the American Burying Beetle (*Nicrophorus americanus*, known also as the Giant Carrion Beetle) received much attention from specialists and agencies: the former for its remarkable life history, massive emergence phenomena, and vulnerability, one localized brood of which was considered likely to become extinct (Manter 1974); the second, as a conspicuous species that had apparently dropped out of most of its range (Anderson 1982).

Later, the charismatic tiger beetles (Cicindelidae), ladybirds (Coccinellidae), bumblebees (Apidae), and many uncommon dragonflies and damselflies would draw significant conservation attention as well as butterflies. Moths too attracted notice; not only the large and popular Saturniidae and *Catocala*, but also endemic Microlepidoptera such as the remarkable flightless *Areniscythris brachypteris*, at risk from sand dune disturbance (Powell 1976).

The Xerces Society functioned strictly as a volunteer organisation for its first decade-plus, under the direction of this writer, then (sequentially) Robert Dirig, Larry Orsak, Mary Hathaway, and Karölis Bagdonas. In 1983, the board hired Xerces' first employee, Melody Mackey Allen, as director of its Monarch Project. At the annual meeting in 1985, again held in Yale, Allen became the first paid executive director, based in Portland, Oregon, where the society is still headquartered. Allen further developed the society's monarch conservation program; initiated the current format of the magazine *Wings*; built a staff; and recruited an extraordinary succession of presidents, including Drs. Jeffrey Glassberg, E. O. Wilson, and Thomas Eisner. That tradition continues today with the society's highly honoured current president, Dr. May Berenbaum.

In 2000, Allen retired and the current executive director, Scott Hoffman Black, was hired. Black has greatly expanded the program base, budget, and staff of the society, focusing especially on pollinators, endangered species, and education, and opening offices in California and the Midwest that concentrate largely on native pollinator programs. The newest office, at Cape May, New Jersey, gives Xerces a continent-wide reach. During his regime, insect conservation has truly become mainstream. Many of Xerces' earliest campaigns, such as the Oregon Silverspot and the Karner Blue, have since become federally listed *causes celebres*, and the society's programs and initiatives receive frequent attention in national media. The Fall 2011 issue of its magazine, Wings, reviews the Xerces Society's first forty years.

Over the same four decades, general attention to insects at risk has grown by a large factor. One can no longer open an issue of the *News* or *Journal of the Lepidopterists' Society* without finding much of the content relating to conservation ecology and management. For example, a recent issue of the journal (Vol. 64, No. 2) begins with a paper entitled 'Breeding evidence for conspecific status of *Grammia phyllira* (Drury 1773) and *Grammia oithona* (Strecker 1878) (Erebidae: Arctiinae), with notes on natural history and conservation status' (Nelson 2010); and contains two additional papers on endangered or threatened species. Papers and posters submitted to the annual meeting programs show the same trend, and investigators and students in many university laboratories are working on questions of rare butterfly and moth ecology and management. The present level of interest is also demonstrated by the many applicants for Xerces' annual Joan Mosenthal DeWind grants to students for research pertaining to Lepidoptera conservation. One of the most striking facts is that the current (2010) president of the Lepidopterists' Society, John Shuey, also serves as chairman of its conservation committee – a long way from the committee's marginal position when first appointed in 1967.

A similar growth of interest and attention may be seen for the other orders, if to a lesser extent, especially for Coleoptera, Odonata, bumblebees, and certain cave and aquatic groups. It cannot be said, however, that this interest has led to proportionate results. Bossart and Carlton (2002) conducted an extensive status review of American insect conservation to date, relying chiefly upon data from the Natural Heritage Programs of the states and both state and federal listings of species. They detected jarring taxonomic and geographic imbalances in the lists of species designated to be of concern or accorded legal protection. They found that 'as the most speciose order, the relative predominance of Coleoptera species on state lists is as predicted. But Lepidoptera and Odonata were disproportionately represented with respect to their contributions to total insect species diversity (although) only a tiny fraction (<1%) of insect species occurring in America are dragonflies or damselflies.' And 'few Diptera and Hymenoptera species are considered at-risk even though these constitute our second and third most speciose orders … and despite their paramount role in natural and managed systems as pollinators, parasites, and decomposers.'

Bossart and Carlton attributed these biases to two 'key' factors: the relative charisma value of taxa, and the patchy distribution and involvement of taxonomic specialists.

Thus they provided statistical demonstration of two common-sense and long-recognized sources of bias that have always dogged field biologists and conservationist officials who try to set priorities for conservation. The traditional terms are 'sexiness of species' and 'collector bias.' Butterflies, big beetles, and dragonflies have always won out in the former arena, and regions and taxa attended by cooperating specialists always get more attention than those without. This is unlikely to change in the near future, as systematists become only fewer. However, one can hope that the problems with reliability highlighted by Bossart and Carlton will stimulate greater attention to underexamined taxa.

In this regard, Bossart and Carlton (2002) pointed out an important and self-defeating, if unintended, consequence that species listing can have: 'When coupled with protective restrictions or regulations,' they write, 'such listings can thwart efforts to gather essential life history and distributional information. The formidable information deficit that characterises insect conservation lists arguably counts as the single most significant impediment to insect-centered conservation. Such regulations are especially frustrating when those largely relied on to identify theoretically sensitive species (i.e., avocational experts) subsequently find the information they provided has been used to establish restrictions that effectively bar their future participation.' For this very reason, I feel listing should sometimes be deferred during the period of vital field survey. In certain cases, according a taxon the pre-listing status of candidate species can serve to focus critical attention and funding for survey and study of it without the counterproductive onus of restrictions.

What may have been the Entomological Society of America's first full symposium on invertebrate conservation since 1930 occurred at their 1995 annual meeting in Las Vegas, under the leadership of David Wagner. Such symposia have since become a regular feature of ESA conventions. At the 1936 ESA meeting, when questions of conservation were raised by Edith Patch, she asked, 'after all, does it seem too unlikely that even before the close of the present century, the majority of economic entomologists will be engaged in the protection of insects (excepting a relatively few actual pests)? To be sure, man has wasted other bounties, with resulting punishment, as witness the soil-erosion disasters of the present time. But will not entomologists be too wise to neglect their opportunity to safeguard the welfare of mankind?'

How remarkable it seems now, almost a century later, during which time we have hardly shown the wisdom Dr. Patch expected of us, to hear her equate 'the welfare of mankind' with 'the protection of insects'! For those of us who have long thought so, her words serve as bracing reinforcement. But they also remind us how little we have advanced along this road. Certainly that 'majority…engaged in the protection of insects' of which she speaks is still but a wraith. The reality, described by Bossart and Carlton in 2002, would not have comforted Edith Patch: 'Until funding is available. . . to support graduate student training and insect-centered conservation research, conservation issues will continue to be regarded as a minor sideline to entomology programs, and entomologists will remain only minor contributors to global and national conservation policy.'

There is no escaping the fact that Paul Ehrlich's Malthusian jeremiad has largely come to pass, with world population having doubled from three to six billion since

The Population Bomb was published; and that many insects stand at great risk from the baleful results of human excess – as do we, ourselves. In the 50 years since Ehrlich's earlier book by that name, we still desperately need to learn 'How to Know the Butterflies', if we are to conserve them – and the rest of the insects, even more so. Yet the history of our efforts to do so is also rich, with many scientists, amateur naturalists, conservation activists, and others taking part along the way.

When we survey the present landscape, we see the Butterfly Conservation Initiative (http://www.butterflyrecovery.org/), dedicated to the conservation of threatened, endangered, and vulnerable North American butterflies and the habitats that sustain them, with a focus on recovery, research, and education. We see Imperiled Butterfly Conservation and Management (http://www.imperiledbutterflies.org/), an intensive cross-training program designed to strengthen the capacity of institutions and their staff to play strategic roles in insect conservation biology, with a focus on imperiled butterfly recovery through captive breeding. The North American Butterfly Association (NABA), as conceived and developed by Jeffrey Glassberg and colleagues, has involved thousands of Americans and Canadians in butterfly observation, with an eye toward their conservation (http://www.naba.org). The Xerces Society is going from strength to strength, having recently filled new positions for pollinator conservation and butterfly conservation specialists (http://www.xerces.org). Impressive use is being made of the internet toward understanding and communicating insect biology (e.g., http://www.butterfliesofamerica.com/).

We see advances in applied biogeography in every state, inspired by John Heath's pioneer work at Monks Wood in Great Britain, notably BAMONA (www.butterfliesandmoths.org/). The popular practice of commercial butterfly releases (e.g., monarchs for weddings), is an active issue of concern over their potential to perturb range studies (Pyle 2010). Faunal surveys and rare species field studies are in progress all over the continent, from investigations of the narrowly endemic and severely wildfire-prone Hermes Copper (*Lycaena hermes*) (Marschalek and Deutschman 2008); to inadvertent effects of intentional burns on prairie rarities such as the Ottoe and Poweshiek Skippers (*Hesperia ottoe, Oarisma poweshiek*) and Regal Fritillary (*Speyeria idalia*) (Swengel 1996, 2001; Swengel et al. 2011); to any number of local and regional monitoring projects (e.g., Chu and Sportiello 2008) and statewide atlas projects (e.g. O'Donnel et al. 2007). The annual Fourth of July Butterfly Counts program, begun by Xerces in 1975 and run by NABA since 1993, now number nearly 500 annual counts. All of these efforts are devoted to what I called in 1967 'a more certain future (for) a continuing rich natural population of butterflies and moths.'

Such a future is far from assured, as shown by collapsing butterfly faunas in parts of California, documented by A.R. Shapiro through multiple transects over many years (http://butterfly.ucdavis.edu/; and Shapiro 2010); and a similarly grim prognosis for much of Florida, especially the Florida Keys (Minno 2011, personal communication, Conservation Committee of the Lepidopterists' Society). Of course a great deal of energy is now and will continue being directed toward the effects of climate change on rare insects (Parmesan et al. 1999; Inouye 2007).

All of these works are still overbalanced toward Lepidoptera, but increasing attention touches on almost every order of insects. Perusal of the publications of the

Xerces Society, the website http://courses.cit.cornell.edu/icb344/abstracts/index.html, and the index of the Journal of Insect Conservation will reward the reader with too many examples to be summarised here. We may take some courage in the progress made to date by all those who care about what E. O. Wilson (1987) described as 'the little things that run the world.'

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Chapter 8
Insect Conservation and the Endangered Species Act: A History

Scott Hoffman Black

8.1 Introduction

As diverse as they are, the Karner Blue butterfly *(Lycaeides melissa samuelis)*, American Burying Beetle *(Nicrophorus americanus)*, Hines Emerald Dragonfly *(Somatochlora hineana)*, and Delhi Sands Flower-loving Fly (*Rhaphiomidas terminatus abdominalis)* share one thing in common: their conservation status has been improved thanks to listing under the United States' Endangered Species Act of 1973 (ESA). Since it first came into law, the ESA has been lauded and reviled in equal measure, and its merits have been debated vigorously. Regardless of people's perceptions, the ESA is the only national law in the United States that specifically protects imperiled insects and their habitats. This chapter looks at the history of this Act as it relates to insects.

8.2 History of the Endangered Species Act

The ESA (and its amendments) is the latest in a long line of United States federal legislation that protects wildlife. Earlier legislation typically provided protection for a single issue or group of animals. The Lacey Act of 1900 prohibited interstate commerce of animals killed in violation of state game laws. The Migratory Bird Treaty Act of 1918 provided protection to birds migrating between the United States and Canada. The Migratory Bird Conservation Act of 1929 created the Migratory Bird Conservation Commission and authorized it to acquire waterfowl

The ESA is the most important legislative tool for the protection of threatened and endangered species in the United States (National Research Council [NRC] 1995).

S.H. Black (✉)
The Xerces Society, 628 NE Broadway, Ste 200, Portland, OR 97232, USA
e-mail: sblack@xerces.org

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refuges. More recently, the Marine Mammal Protection Act of 1972 prohibited the taking of marine mammals.

The first major legislative step which foreshadowed the current Endangered Species Act was the passage of the Endangered Species Preservation Act of 1966 (Schreiner 1978), which directed the Secretary of the Interior to conserve, protect, restore, and propagate selected species of native fish and wildlife. This Act also provided authority for the acquisition of land for habitat protection and charged the Secretary to determine whether a species was threatened with extinction. The protection applied only to domestic vertebrate species of fish and wildlife (terrestrial mammals and birds), and did not extend to plants, subspecies, or population segments. Insects were excluded from consideration (NRC 1995; Pyle et al. 1981).

Three years later, the definition of fish and wildlife was expanded to include mollusks and crustaceans by passage of the Endangered Species Conservation Act of 1969 (Bean 1993; Petersen 1999; Schreiner 1978). In addition, this Act authorised the Secretary of the Interior to promulgate a list of species or subspecies of fish and wildlife threatened with extinction and to prohibit their importation into the United States. Despite the important new provisions, the law did not give legislative authority to protect insects (NRC 1995; Pyle et al. 1981).

In 1972 President Nixon called for adoption of 'a stronger law for the protection of endangered species'. He claimed that the 1969 law did not provide the management tools needed to act early enough to save a vanishing species (Petersen 1999).

Congress passed the Endangered Species Act in 1973 and it was signed by President Nixon on December 28 of that year. In his signing statement, President Nixon declared that 'Nothing is more priceless and more worthy of preservation than the array of the animal life with which our country has been blessed. It is a many-faceted treasure, of value to scholars, scientists, and nature lovers alike, and it forms a vital part of the heritage we all share as Americans.'

This Act has been described as the broadest and most powerful wildlife protection act in U.S. history (Bean 1993; Connor et al. 2002; NRC 1995; Pyle et al. 1981; Schreiner 1978) and has served as a model of species protection for many other nations (Losos 1993). In this Act, Congress recognised that insects are a significant natural resource, marking the first time that insects received specific federal protection in the U.S. (Bean 1993; Connor et al. 2002; NRC 1995; Pyle et al. 1981; Schreiner 1978; U.S. Fish and Wildlife Service [USFWS] 2008). Protection of endangered native plants received consideration for the first time. Protection of these plants and their habitats may provide some protection for host specific insects (Schreiner 1978).

8.3 The Protective Power of the ESA

It is noteworthy that the main stated purpose of the ESA is 'to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved.' The power of the ESA to achieve this lies with its stringent mandate constraining actions on both private parties and public agencies. Once a species is listed as threatened or endangered, it is protected by an impressive and far-reaching array of provisions (NRC 1995).

First, the ESA gives the Secretary of the Interior authority to acquire land on behalf of any listed species (Schreiner 1978). Sections 5 and 6 of the ESA provide for funds for habitat acquisition by federal agencies and for conservation efforts by individual states (NRC 1995). This has been a very important provision for insects with limited range and has provided for purchase of habitat for various endangered species. In recent years, millions of dollars have been appropriated to purchase habitat for species such as the Carson Wandering Skipper *(Pseudocopaeodes eunus obscurus)* and the Salt Creek Tiger Beetle *(Cicindela nevadica lincolniana)*.

Second, Sect. 7 calls for the cooperation of all federal agencies in the conservation of any listed species whose habitats occur on land under their jurisdiction, or which might be affected by their actions, as well as any actions funded or authorised by them. This provision of interagency cooperation is one of the most powerful parts of the ESA (Schreiner 1978). Section 7 of the ESA prohibits any federal action likely to jeopardise the future of any endangered species or to result in destruction or adverse modification of designated critical habitat. This provision extended beyond listed species as federal agencies have an incentive to conserve candidate and sensitive species so they ultimately do not become listed. For example, in Oregon and Washington, the joint Forest Service/Bureau of Land Management Interagency Special Status/Sensitive Species Program has appropriated funding for surveys, research, management plans, and direct conservation efforts for multiple insects so that they will not ultimately be listed.

Third, endangered species receive extremely strong direct protection. It is illegal to take an endangered species of animal (and by subsequent regulation, threatened species), in the U.S. and its territorial waters (NRC 1995). The term 'to take' is defined as 'to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.' Limited taking may occur under federal permits for research purposes (NRC 1995).

In addition, Sect. 4 of the ESA requires critical habitat to be designated and recovery plans to be written unless they will not promote conservation of the species (NRC 1995). The plans must include specific population goals, timetables, and estimated costs although not all recovery plans are adequate. Schultz and Hammond (2003) reviewed 27 recovery plans for U.S. listed insects and found that recovery criteria were often poorly linked with species biology.

Other important provisions include participation by the public in determination of which species should be listed (Schreiner 1978). Indeed since 1980 most species have been protected because of petitions brought forward by scientists, conservation groups, and other citizens. Citizen groups using provisions that enforce compliance with the ESA have ensured that species are protected even when the U.S. government has worked to limited protection under the ESA.

8.4 Agencies That Implement the ESA

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibility for implementing the ESA. Generally, USFWS manages terrestrial and freshwater species, while NMFS manages marine and 'anadromous' species.

8.5 Insects and the ESA

Before 1973, federal laws aimed at preserving species applied only to vertebrates. Passage of the ESA that year extended coverage to all plants and invertebrate animals, bringing U.S. policy into line with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which was also ratified in 1973.

That said, large charismatic species drove the popular demand for the passage of the ESA and because they are relatively well known, from both scientific and popular standpoints, birds, mammals, and fish have captured most research, management, and funding associated with the ESA (NRC 1995).

In 1974 the U.S. Fish and Wildlife Service's Office of Endangered Species employed Dr. Paul Opler as it first Staff Specialist in Entomology, thus lending official recognition and responsibility to the conservation of rare insects (Pyle 1976). Dr. Opler's arrival resulted in quick changes. In 1975, 41 species and subspecies of insects were proposed as candidates for listing under the ESA. In 1976 the first insects – the Bahama Swallowtail *(Heraclides andraemon bonhotei)* and Schaus Swallowtail butterflies *(Heraclides aristodemus ponceanus)* – were officially designated as endangered (Bean 1993). Federal listing of six California butterflies soon followed (Pyle 1995). One of these, the Palos Verdes Blue *(Glaucopsyche lygdamus palosverdesensis)*, apparently became extinct in spite of protection from the ESA because of habitat damage due to development for a park (Bean 1993), but 11 years later in March 1994, was rediscovered by Rudi Mattoni and colleagues on naval land (Mattoni 1992; Pyle 1995). Nevertheless, these early listings did lead to real protection. One early success of the ESA, in regards to insect conservation involves the Lange's Metalmark *(Apodemia mormo langei)*, a butterfly endemic to isolated sand dunes along the Sacramento River in Contra Costa County, California. The listing of Lange's Metalmark led to the establishment of the Antioch Dunes National Wildlife Refuge, the first wildlife refuge in the U.S. designed to promote a rare insect (Connor et al. 2002). This 23 hectare site cost the U.S. government $2.1 million (Orsak 1978).

8.5.1 Delisting and the ESA

The USFWS uses recovery criteria detailed in the recovery plan to determine if a species should be removed from the Endangered Species Act. At present no insect has recovered sufficiently to be taken off the list of endangered or threatened species. The first insect officially listed, the Bahama Swallowtail butterfly (*Heraclides andraemon bonhotei*), was taken off the list because of an ESA amendment (it was determined to be only an occasional stray in the US and the authority to protect discrete invertebrate populations was ended by the 1978 amendments to the ESA).

Some people have pointed out that the ESA must not work because few species have reached full recovery. Measuring effectiveness of the ESA using only these endpoints is overly simplistic and also ignores the fact that recovery of species may take decades (Norris 2004; Male and Bean 2005). One study has found that the majority of species listed under the ESA showed repeated improvements or were not declining over time and showed that species status improves over time since listing, with only 35% still declining 13 years or more after protection (Male and Bean 2005). These findings suggest that many species protected by the ESA have made progress toward recovery. Although one analysis suggests a lower percentage of invertebrates are recovering than vertebrates (Taylor et al. 2005), this may be an artifact that many species have not been listed long enough to show recovery (Male and Bean 2005).

8.5.2 The Butterfly That Changed the ESA

The ESA was amended in 1983 in order to permit taking of listed taxa, including after approval of a habitat conservation plan (Pyle 1995). This amendment was designed to remove the obstacle that the endangered Mission Blue *(Icaricia icarioides missionensis),* and several other listed species presented to developers on the San Bruno Mountain, south of San Francisco, in California (Cushman and Murphy 1993). This site represented the largest undeveloped parcel of private land on the San Francisco peninsula. Proposed housing developments were delayed until the impact on the survival of these butterflies could be determined (Connor et al. 2002). Under the ESA as originally written, any destruction of habitat for these butterflies was considered a ‘take’, and was prohibited. A political compromise between developers and the U.S. government led the U.S. Congress to change Sect. 10a of the ESA (Cushman and Murphy 1993; Nelson 1999). These changes allowed for incidental take of endangered species as long as the actions do not jeopardise the survival of the species. Development is allowed in the context of an approved Habitat Conservation Plan (HCP) that mitigates harm to endangered species. The Mission Blue led to the ESA’s first HCP, a mechanism that some hail as a creative means of resolving development and species conservation controversies (Bean 1993). Under this HCP land was preserved while other lands, including habitat for the butterflies, were developed for housing. This was a divisive issue in Lepidoptera conservation circles. The Xerces

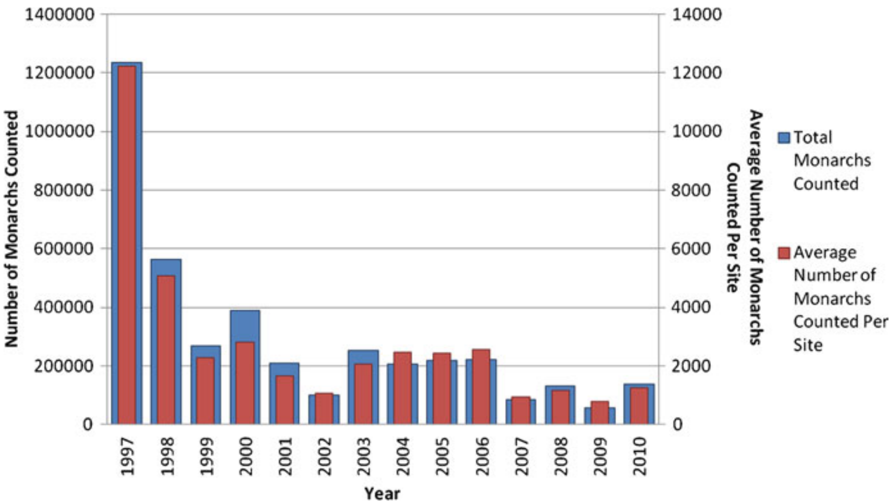

Fig. 8.1 Monarch clusters in California demonstrate a nearly 90% decline (Developed from data from Frey et al. 2010)

Society and the International Union for Conservation of Nature opposed it, contending that the expertise to re-create critical habitat did not exist, and that there were too many unknown factors (Pyle 1995). Others felt that the survival of the ESA lay in the balance and supported the compromise (Pyle 1995). The San Bruno Mountain HCP provided a model that is used nationwide to allow land development, even in the presence of endangered species (Connor et al. 2002). This HCP remains controversial, as is the overall concept of HCPs (Kareiva et al. 1999).

8.5.3 Unequal Protection Under the Law

Although the ESA did initially provide the same protection for insects as it did for vertebrate animals, in 1978 the United States Congress passed an amendment that significantly weakened the law for insects and other invertebrates (Orsak 1978). These changes restricted the protection of distinct population segments to vertebrate animals only (Bean 1993). This was a compromise between the House and the Senate; the House had voted to eliminate protection for invertebrates altogether (Bean 1993). This provision has real world implications.

Monarch butterflies (*Danaus plexippus*) are noted for their long distance migrations beginning each spring from overwintering sites in Mexico. A distinct population of Monarchs is also found west of the Rocky Mountains, and overwinters at various sites in central and southern coastal California (Malcolm and Zalucki 1993). This distinct population has undergone marked declines over the last 13 years. Between 1997 and 2010, annual Thanksgiving counts of overwintering Monarch clusters in California demonstrate a nearly 90% decline (Frey et al. 2010) (Fig. 8.1).

In 1997, over 1,000,000 Monarchs were counted at overwintering sites while in 2010 only 139,460 Monarchs were counted. The average number of Monarchs per site decreased from 12,232 to 1,256 (Frey et al. 2010) (Fig. 8.1). Even though this geographically distinct Monarch population has seen a more than 90% decline, it could not be listed because listing is not allowed for a distinct population segment of an insect.

8.6 Politics and the ESA

It is the nature of politics that administrations have differing priorities and outlooks on the protection of endangered plants and animals. For example, in 1975, as governor of California, Ronald Reagan declared his doubt that insects need any protection: '….in spite of our all out war against certain undesirable insects over countless years we've failed to eliminate a single species' (Berenbaum 2008).

This animosity continued into his Presidency, when in his second year in the White House, the ESA was revised to exclude any insects that in any life stage or in any part of their range present a risk to agriculture (Bean 1993). The provision has never been used since most species on the brink of extinction would not qualify as a pest. One example of an at-risk species that might meet the definition of a pest is the Ashton Cuckoo Bumble Bee (*Bombus ashtoni*). Cuckoo bumble bees are parasites of other bumble bees and losses of cuckoo bumble bees should serve as a warning that other bumble bees are disappearing. There is substantial evidence that the Ashton Cuckoo Bumble Bee has disappeared throughout its range, yet because it might be considered a 'pest' of commercially important bumble bee species it is unclear whether it could be listed under the ESA.

This negative attitude to insects was reflected in the fact that listings of insects under the ESA ceased during the Administration of President Reagan until Stanford University biologists sued the U.S. Fish and Wildlife Service to list the Bay Checkerspot (*Euphydryas editha bayensis*) (Murphy and Weiss 1988). A total of six insects were listed in 8 years under this administration.

Under the George H. Bush Administration, listing of insects resumed, albeit at a low level (7 listed in 4 years) and continued in the Clinton Administration (17 listed in 8 years), but they essentially stopped under the George W. Bush Administration – until lawsuits compelled the administration to act. As May Berenbaum (2008) wryly noted 'Unfortunately, listings have been more influenced by political climate change than ecological climate change.'

Under the George W. Bush Administration, the U.S. Fish and Wildlife Service often did not follow the law or accept the recommendations of its own scientists in making decisions regarding ESA listing and critical habitat. Below are just some of the many examples where the law was not followed by this administration. All were part of congressional testimony on problems with implementing the ESA (Black 2008).

Miami Blue butterfly (*Hemiargus thomasi bethunebakeri*)
This butterfly was originally petitioned for listing when there were fewer than 100 individuals known to exist. The field office and region prepared an emergency rule to list the species because it was limited to one population and threats were imminent. But after 2 years the national office failed to follow through on the listing even though all of the information available showed that listing was both scientifically and legally justified. As of August 10 2011, a lawsuit has compelled the USWFS to grant emergency status for this butterfly under the ESA.

Twelve species of Hawaiian Picture-wing flies (*Drosophila* spp.)
In 2006 the USFWS ignored recommendations of scientists to set aside 9,200 acres of critical habitat for 11 species of endangered Picture-winged flies (*Drosophila* spp.), opting instead to set aside only 18 acres. An outcry from scientists and a lawsuit from conservation groups ultimately led the USFWS to reverse the decision.

Salt Creek Tiger Beetle (*Cicindela nevadica lincolniana*)
A multi-agency team of scientists initially proposed over 36,000 acres of critical habitat for the recovery of the Salt Creek tiger beetle. At the prompting of the USFWS, this team revised the proposal to 15,000 acres of critical habitat. In 2006 the USFWS then proposed only 1,795 acres of critical habitat. One scientist on the team has called the decrease from 15,000 acres to 1,795 acres ludicrous. A lawsuit has compelled the USFWS to reassess the acreage of critical habitat.

Island Marble butterfly (*Euchloe ausonides insulanus*)
In 2006 the USFWS denied the listing of this butterfly, which has a population estimated to be fewer than 1,000 individuals. There continue to be multiple threats to the survival of this butterfly. The field office initially was preparing a rule to list the species, but the regional office re-wrote the decision to not list it.

8.6.1 The Vilified Fly

For most insects, conservation efforts have gone forward in relative obscurity, generating little controversy. Whereas the proposed reintroduction of species such as the grey wolf in Yellowstone National Park had been intensely controversial, the American burying beetle and other invertebrates have been reintroduced without contention (Bean 1993). However, there have been some notable exceptions to this.

Thanks to the persistence of Greg Ballmer, an entomologist at University of California at Riverside, the Delhi Sands Flower-Loving Fly – a specialist of inland sand dune habitat that is now only found on a few sites in San Bernadino County, California, just east of Los Angeles – was listed under the ESA in 1993. This listing has led to much backlash against the ESA and the listing of insects. The fly has been held responsible for halting development projects across the county; citizens and the then-mayor of the city of Colton regularly showed up at meetings with giant fly swatters. However, the facts show that few developments have been stopped. One accusation stated that the construction of the $600 million Arrowhead Medical

Center in Colton was stopped because of the fly and the hospital could not use 40% of the site for any construction. In fact, the hospital construction was never halted. Before construction began an agreement was reached with the developer to set aside less than 10 acres of habitat for the fly out of an approximately 70 acre site. Detractors have also claimed that 1,600 jobs would be lost – or at least not created – because of development restrictions around the fly's habitat, which turned out to be a baseless accusation. This misinformation led the U.S. House of Representatives Committee on Natural Resources to hold a field hearing with the ostensible purpose of gauging public support for the endangered Delhi Sands Flower-Loving fly and the ESA. Despite the official-sounding title, this 'hearing' was not the Congressional fact-finding mission that it was touted to be, but an attempt to push for provisions that would weaken the ESA.

8.7 Does the ESA Adequately Reflect the Number of Insects That Are Threatened or Endangered?

In the United States, both the USFWS and NatureServe track endangered species, including insects. Under the aegis of the ESA, the USFWS lists 590 animals as either endangered or threatened, of which only 61 are insects (Fig. 8.2, Table 8.1; USWFS 2012a and 2012c). Based on available information we can deduce that a much larger number of insects are at-risk but receive no formal protection.

A small proportion, 10.3%, of the endangered or threatened animal species listed by the USFWS are insects, yet insects make up more than 72% of global animal diversity. If we look at it another way, of all the vertebrates described in the United States, approximately 18% are listed as threatened or endangered. Even if we assume nothing more than that insects face similar destructive forces as vertebrates and at similar levels of intensity, then one should expect to find in the order of 16,000 at-risk insects in the United States alone (Black and Vaughan 2009). Although this assumption oversimplifies the situation, it underscores that with only 61 taxa listed as endangered and threatened under the ESA, insects are significantly underrepresented.

NatureServe lists 1,688 insects as either critically imperiled or imperiled, based on data from state Natural Heritage Programs (NatureServe 2012). Looking more closely at select groups of the critically imperiled or imperiled insects on its lists, the Heritage Program estimates that 21% of stoneflies, 10% of tiger beetles, 6% of butterflies, and 8% of dragonflies and damselflies are critically imperiled or imperiled in the United States (Wilcove and Master 2005). It is worth noting that no stoneflies are listed under the ESA (Fig. 8.3; USFWS 2012a). In addition, the Xerces Society has produced a 'Red List of Pollinator Insects of North America'. Fifty-one bees are listed as critically imperiled, imperiled, or vulnerable, but none receive any federal protection (Shepherd et al. 2005).

Interestingly there are more insects on the federal candidate list than any other group (Fig. 8.4; USFWS 2012b). Federal candidates are species that the USFWS has found warrant protection under the ESA but have been denied protection because the agency has higher priorities and not enough funding.

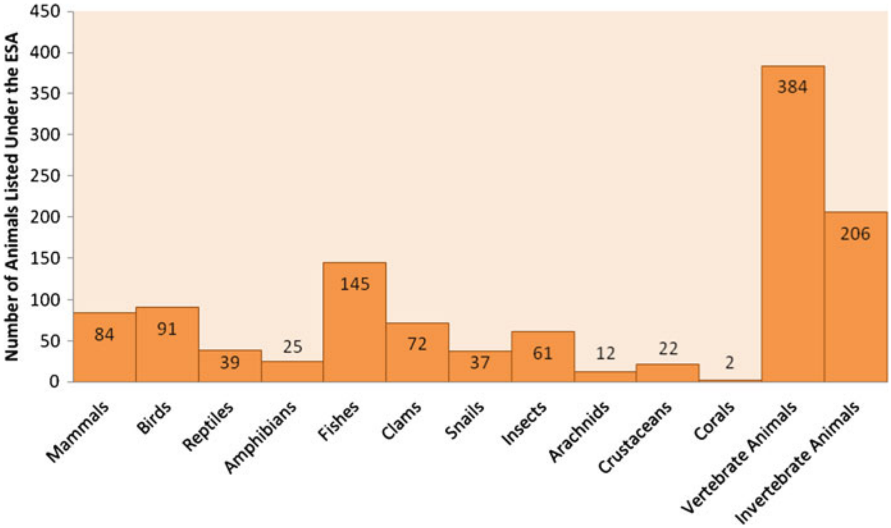

Fig. 8.2 USFWS lists 590 animals listed as either endangered or threatened, of which only 61 are insects (USFWS 2012c)

8.7.1 The Charisma Factor

To compound the bias in legislation and regulation and the handicap of a lack of information on life history and threats, insects may be facing an identity crisis. Charisma may play a role in limiting how much information is available to promote a listing, who supports or advocates for protection, and thus, which species ultimately are listed. This is evident in the striking overrepresentation in butterflies – arguably the most studied and charismatic insects – among insects protected by the ESA. Although butterflies make up less than 1% of all insect taxa in the United States, they comprise more than 40% of the listed insect species (Fig. 8.3; USFWS 2012a). The listing of these butterflies may ultimately help other insects as formal recognition of the plight of many butterflies has been instrumental in maturing the science of insect conservation (New 1999).

Bias toward charismatic species is not limited to the ESA. Clark and May (2002) found that it is pervasive in organismal research and in the conservation literature; i.e., the amount of research is not proportional to organisms' frequency in nature. This also pervades public opinion (Czech et al. 1998; Kellert 1993).

Barriers to raising public awareness and mobilising support for protection of insects may be as simple as the lack of a pronounceable and informative common name (Berenbaum 2008). All of the 84 mammals listed by the ESA as endangered or threatened have a common name. In comparison, of the 61 listed insects, 14 – almost 23% – have no common name.This lack of names may impede conservation efforts because information used to define conservation priorities is frequently based on the personal

Table 8.1 All insects listed under the US Endangered Species Act as of January 2012

Order	Common name	Scientific name	Date of listing	Listing status
Coleoptera				
	American Burying beetle	*Nicrophorus americanus*	13.VII.1989	Endangered
	Caseys June beetle	*Dinacoma caseyi*	24.X.2011	Endangered
	Coffin Cave Mold beetle	*Batrisodes texanus*	16.IX.1988	Endangered
	Comal Springs Dryopid beetle	*Stygoparnus comalensis*	18.XII.1997	Endangered
	Comal Springs Riffle beetle	*Heterelmis comalensis*	18.XII.1997	Endangered
	Delta Green Ground beetle	*Elaphrus viridis*	8.VII.1980	Threatened
	Helotes Mold beetle	*Batrisodes venyivi*	26.XII.2000	Endangered
	Hungerford's Crawling Water Beetle	*Brychius hungerfordi*	7.III.1994	Endangered
	Kretschmarr Cave Mold beetle	*Texamaurops reddelli*	16.IX.1988	Endangered
	Mount Hermon June beetle	*Polyphylla barbata*	24.I.1997	Endangered
	Tooth Cave Ground beetle	*Rhadine persephone*	16.IX.1988	Endangered
	Valley Elderberry Longhorn beetle	*Desmocerus californicus dimorphus*	8.VII.1980	Theatened
	(Unnamed) ground beetle	*Rhadine exilis*	26.XII.2000	Endangered
	(Unnamed) ground beetle	*Rhadine infernalis*	26.XII.2000	Endangered
	Northeastern Beach tiger beetle	*Cicindela dorsalis dorsalis*	7.VII.1990	Threatened
	Ohlone tiger beetle	*Cicindela ohlone*	3.X.2001	Endangered
	Puritan tiger beetle	*Cicindela puritana*	7.VII.1990	Threatened
	Salt Creek Tiger beetle	*Cicindela nevadica lincolniana*	6.X.2005	Endangered
Diptera				
	Delhi Sands Flower-Loving fly	*Rhaphiomidas terminatus abdominalis*	23.IX.1993	Endangered
	Hawaiian picture-wing fly	*Drosophila sharpi*	13.V.2010	Endangered
	(unnamed) pomace fly	*Drosophila aglaia*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila differens*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila hemipeza*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila heteroneura*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila montgomeryi*	9.V.2006	Endangered

(continued)

Table 8.1 (continued)

Order	Common name	Scientific name	Date of listing	Listing status
	(unnamed) pomace fly	*Drosophila mulli*	9.V.2006	Threatened
	(unnamed) pomace fly	*Drosophila musaphila*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila neoclavisetae*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila obatai*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila ochrobasis*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila substenoptera*	9.V.2006	Endangered
	(unnamed) pomace fly	*Drosophila tarphytrichia*	9.V.2006	Endangered
Hemiptera				
	Ash Meadows naucorid	*Ambrysus amargosus*	20.V.1985	Threatened
Lepidoptera				
	Bay Checkerspot butterfly	*Euphydryas editha bayensis*	18.IX.1987	Threatened
	Behren's Silverspot butterfly	*Speyeria zerene behrensii*	5.XII.1997	Endangered
	Callippe Silverspot butterfly	*Speyeria callippe callippe*	5.XII.1997	Endangered
	El Segundo Blue butterfly	*Euphilotes battoides allyni*	8.VI.1976	Endangered
	Fender's Blue butterfly	*Icaricia icarioides fenderi*	25.I.2000	Endangered
	Karner Blue butterfly	*Lycaeides melissa samuelis*	14.XII.1992	Endangered
	Lange's Metalmark butterfly	*Apodemia mormo langei*	8.VI.1976	Endangered
	Lotis Blue butterfly	*Lycaeides argyrognomon lotis*	8.VI.1976	Endangered
	Mission Blue butterfly	*Icaricia icarioides missionensis*	8.VI.1976	Endangered
	Mitchell's Satyr Butterfly	*Neonympha mitchellii mitchellii*	25.VI.1991	Endangered
	Myrtle's Silverspot butterfly	*Speyeria zerene myrtleae*	22.VI.1992	Endangered
	Oregon Silverspot butterfly	*Speyeria zerene hippolyta*	2.VII.1980	Threatened
	Palos Verdes Blue butterfly	*Glaucopsyche lygdamus palosverdesensis*	2.VII.1980	Endangered
	Quino Checkerspot butterfly	*Euphydryas editha quino*	16.I.1997	Endangered
	Saint Francis' Satyr butterfly	*Neonympha mitchellii francisci*	18.IV.1994	Endangered
	San Bruno Elfin butterfly	*Callophrys mossii bayensis*	8.VI.1976	Endangered
	Schaus Swallowtail butterfly	*Heraclides aristodemus ponceanus*	28.IV.1976	Endangered
	Smith's Blue butterfly	*Euphilotes enoptes smithi*	8.VI.1976	Endangered

	Uncompahgre Fritillary butterfly	*Boloria acrocnema*	24.VI.1991	Endangered
	Blackburn's Sphinx moth	*Manduca blackburni*	1.II.2000	Endangered
	Kern Primrose Sphinx moth	*Euproserpinus euterpe*	8.IV.1980	Threatened
	Carson Wandersing skipper	*Pseudocopaeodes eunus obscurus*	29.XI.2001	Endangered
	Laguna Mountains skipper	*Pyrgus ruralis lagunae*	16.I.1997	Endangered
	Pawnee Montane skipper	*Hesperia leonardus montana*	25.IX.1987	Threatened
Odonata				
	Flying Earwing Hawaiian damselfly	*Megalagrion nesiotes*	26.VII.2010	Endangered
	Hine's Emerald dragonfly	*Somatochlora hineana*	26.VII.2010	Endangered
	Pacific Hawaiian damselfly	*Megalagrion pacificum*	26.I.1995	Endangered
Orthoptera				
	Zayante Band-Winged grasshopper	*Trimerotropis infantilis*	24.I.1997	Endangered

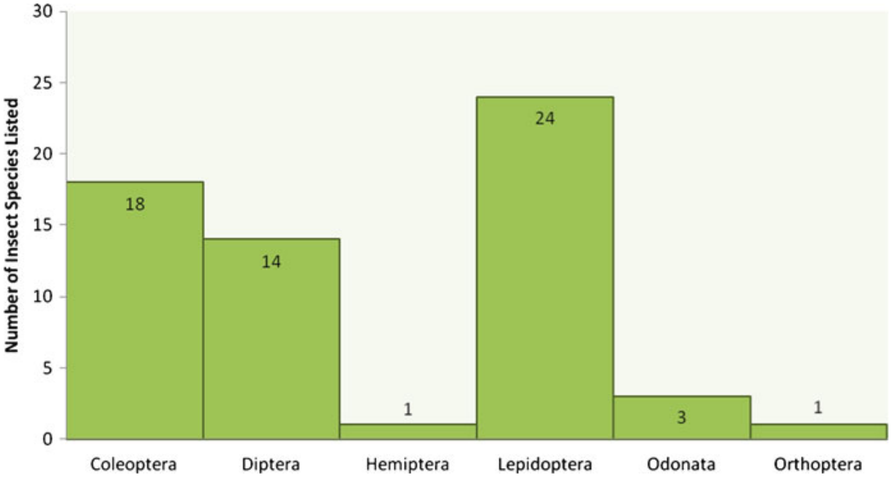

Fig. 8.3 ESA listed endangered and threatened insect species grouped by insect order (USFWS 2012a)

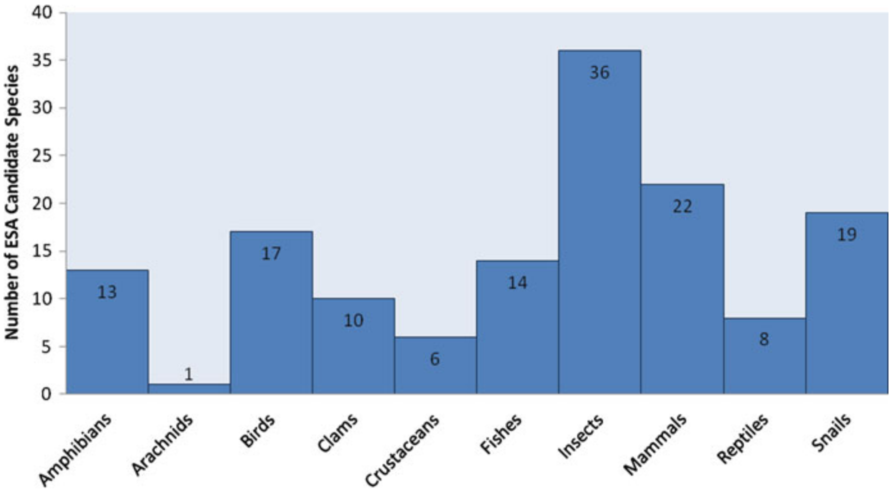

Fig. 8.4 There are more insects on the federal candidate list than any other group (**This depiction includes candidate species that have distinct population segments; each distinct population segment is counted as one species) (USFWS 2012b)

interests of scientists (Martín-López et al. 2009), and listing of insects may reflect interest by scientists and advocacy groups. Consequently, animals with no identity can be overlooked. A dedicated group working toward the conservation of insects may be strongly linked with the number of species that are listed. The Xerces Society was one of the driving forces in the early listing of butterfly species. Paul Opler, as first Staff

Specialist in entomology with the USFWS office of Endangered Species, and Xerces Society members and officers worked to get many of the butterfly species listed.

The lack of a mobilised constituency certainly holds true for aquatic insects. Only four aquatic insects are listed under the ESA even though there is evidence that many more are undoubtedly imperiled. Opler (1993) noted there is a need for both individual scientists and appropriate organisations to petition the Fish and Wildlife Service to support listing of endangered or threatened aquatic insects, as well as a strong need for developing databases of aquatic insects of conservation concern.

Some non-charismatic animals receive significant protection. Freshwater mussels are arguably similar to insects in that they are hard to identify, hard to study, and are not charismatic, and yet, to date 72 species of mussels have been listed under the ESA, more than any other invertebrate group and more than the listed reptiles and amphibians combined. This does suggest that even non-charismatic groups can receive protection if there is an engaged constituency.

8.8 Lack of Funding for Listed Species

Budget cuts to the USFWS have been a serious problem since the 1970s (Orsak 1978), and recovery of listed species is hampered by a lack of funding. This is chronic for invertebrates despite the equal status given to all species under the ESA. Many studies have pointed out this disparity. For example, New (1995) documented that in 1990 more than 90% of the funding went to fewer than 10% of listed species – and that none of these was an insect. Recovery spending is also less for invertebrates as a whole. Although recovery costs are expected to be lower for plants and invertebrates because they often need less habitat for recovery, they make up more than 73% of endangered species yet receive only 12.5% of USFWS and NOAA funding (Male and Bean 2005). The majority of funding goes to charismatic mammals, birds, and fish. In this respect, the successes or failures of the ESA are driven as much by implementation decisions as by the statute itself (Male and Bean 2005).

8.9 The ESA vs Ecosystem Protection

The approach taken to most invertebrate conservation is modeled on that used for vertebrates, in which an intensive, species-based approach demands a large amount of information to target a species for legal protection and to carry out a recovery plan. Some have argued for an ecosystem approach for insects (Polhemus 1993; Strayer 2004). Strayer (2004) noted that an individual species approach will be woefully inadequate for freshwater invertebrates because too many are in danger and we know too little about them. Others have pointed out that an ecosystem service-based approach to conservation may be beneficial (Losey and Vaughan 2008).

There are many examples of how the ESA has worked to conserve particular insect species, but there is a general consensus that it is not enough on its own to protect the broad diversity of insect taxa in the U.S. (Wilcove and Master 2005). As Wilcove and Master (2005) stated, 'No additional data are needed to conclude that the ESA by itself will not adequately protect the US's imperiled species, now or in the foreseeable future.'

A broadly shared goal of conservation biologists is to identify groups that can serve as surrogates or indicators for lesser-known groups. Unfortunately, the evidence to date on the efficacy of this approach is equivocal (Wilcove and Master 2005). Another approach, using ecological communities as a kind of 'coarse filter' to protect little known species is favoured by many conservation biologists and non-government organisations. But if the distributions of rare invertebrates do not correspond to the way the ecological communities are defined, this approach will fail to protect many imperiled species (Wilcove and Master 2005).

Consensus exists among conservation biologists that conservation measures should integrate protection on several levels, including genes, species, and ecosystems (Losos 1993). But there is debate about whether the ESA in its current form is sufficient to maintain biodiversity or whether an ecosystem approach would be better (Losos 1993). Some conservation biologists argue that the species approach is inherently an emergency room strategy, working only to bring the species back from the brink of extinction (Losos 1993). Supporters of the ESA maintain that it was designed to allow habitat and ecosystem protection along with species and subspecies protection. Proponents of the ESA maintain that a pure ecosystem approach may also be troubled by practical and political pitfalls (Losos 1993). One hurdle to the ecosystem approach is that although many classifications of ecosystems have been suggested, there is no universally accepted standard (Losos 1993). By comparison, the species definition is widely accepted and easily determined. Even if ecosystems were well defined, translating biodiversity into the regulatory context can be plagued with difficulty (Dudley 1992). Species that are threatened by factors other than habitat destruction, such as native bumble bees threatened by introduced disease, are particularly vulnerable to this problem (Evans et al. 2008). Furthermore, under the ecosystem approach ecologists would be forced to choose between ecosystems containing different assemblages of species (Dudley 1992). In a panel discussion on the ESA, evolutionary and conservation biologist Michael Soulé noted 'Those who advocate the ecosystem approach, while their ideals are admirable, may be playing onto the hands of those wishing to destroy the ESA' (Losos 1993). Conservationists should mobilise to broaden the ESA rather than criticising it while pinning their hopes on new legislation that would chase the siren songs of ecosystem diversity (Losos 1993). The ESA (especially when well funded) is an integral part of protecting overall biodiversity. It remains the best insurance program that ecologists have (Losos 1993).

8.10 Conclusion

The record of accomplishment of the ESA for insects is modest but significant. This may be due more to implementation of the law and to societal factors that favour vertebrates more than the law itself. A chronic lack of funding, lack of scientific attention to many insect groups and a lack of action by conservation groups all lead to less conservation attention.

The good news is that some insects are showing signs of recovery and others might now be extinct if not for this law. A more engaged constituency in support of insects may be what the ESA needs to protect a greater number of taxa. Certainly, more funding and a greater focus on insects would significantly improve the benefits from this law. The ESA is one valuable and necessary tool in our efforts to conserve biodiversity because it is a safety net for those species in most danger of extinction (Tear et al. 1995). Since official listing will never reflect the true status of rare and declining insects, it is also important to look at other approaches such as protecting ecosystems and restoration efforts for entire groups of animals such as pollinators. One very important aspect of the ESA is that it has drawn attention to the fact that the crisis of extinction confronts not just birds and mammals, but the myriad of less conspicuous, but no less important animals (Bean 1993). That attention has helped mobilise significant resources to focus on the conservation of species about which few were aware or concerned until recently (Bean 1993).

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Part III
The Temperate Southern Regions

Chapter 9
Insect Conservation in Australia

Tim R. New and Alan L. Yen

9.1 Introduction and Early Perspective

Insect conservation is generally a 'young discipline' in Australia and interest has developed mainly since the 1970s. The slightly over 200 years of European settlement of Australia have been associated with massive alterations to natural environments, and rapid changes have enforced impressions of the contrast between modern anthropogenic environments and the more pristine ones that persist. They are associated also with Australia having an unenviably high record of vertebrate extinctions and substantial proportions of extant vertebrates threatened. There is little reason to doubt that invertebrates have also suffered significant losses, but these have not been documented in parallel detail. Extirpations of some butterflies, for example, have been reported intermittently since the late nineteenth century (Waterhouse 1897) but there is no historical record equivalent to the information available in the United Kingdom or United States.

The insect fauna of much of Australia is still poorly known, reflecting the remoteness of many areas and the small number of naturalists who have penetrated the less accessible regions. As an 'island continent', Australia spans climatic regimes from the wet tropics to cold temperate zones, with corresponding variety of vegetation and terrain. Amongst this, many biotopes are localised and restricted. The insect fauna of many is very incompletely documented, with progressive work revealing considerable and sometimes unexpected variety of locally endemic species.

T.R. New (✉)
Department of Zoology, La Trobe University,
Melbourne 3086, Victoria, Australia
e-mail: t.new@latrobe.edu.au

A.L. Yen
Biosciences Research Division, Department of Primary Industry,
621 Burwood Highway, Knoxfield, VIC 3156, Australia

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Thus, the diverse assemblages of water beetles each characteristic of individual calcrete aquifers in Western Australia have been likened to 'subterranean islands with independently evolved taxa' (Cooper et al. 2002). Many such local biota are under threat from anthropogenic changes. The small alpine/ subalpine areas on the south east mainland, for example, are subject to increased development for recreation, with the prospect of climate change a likely compounding threat to many ecologically restricted insects there.

The relative 'youth' of Australia, and the conditions in which it was settled by Europeans, has meant that natural history traditions have been far less developed – so, for example, there have never been large numbers of butterfly collectors, beetle enthusiasts, or other insect hobbyists at any given time (Moulds 1999). Those few have had to come to terms with a vast fauna occurring over a massive area, much of it inhospitable and – even now, but particularly in the past – difficult and expensive to explore. Australia's insect fauna comprises at least 100,000 species, perhaps more than twice this number (Yeates et al. 2003), of which perhaps only a quarter have been described, and about three quarters are endemic They include many ancient Gondwanan lineages which, together with high levels of endemism also in other faunal elements, furnish global evolutionary significance. The southern lineages intermingle with northern faunal elements derived from the Oriental fauna by successive invasions, and all are now overlain by recent introductions or invasive aliens arriving since European settlement from the late eighteenth century. Other than for relatively few species that have been nominated for conservation significance, there has been little quantitative evaluation of numbers of threatened insect taxa, and Clarke (2001) noted that much of the initial awareness was by museum-based systematists, so that wider biological evaluation of threats and distributions lagged.

European settlement of Australia centred initially on a number of coastal sites that are now the country's major metropolises. Subsequent development is associated with massive clearing of native vegetation for urbanisation, agriculture and, progressively, for forestry, wider industrialisation such as mining, and recreation, to the extent that many formerly widespread vegetation associations have been reduced to small fragments, or lost. Even tiny remnants of communities such as lowland native grasslands in the south east are important refuges or, in some cases, reserves for insects that have been extirpated across the wider enveloping landscape. Changes also involved drainage of wetlands, and introduction (by design or accident) of vast numbers of alien animals and plants. Many, even most, vegetation and freshwater remnants thus now support resident exotic species. Trout, for example, are associated with losses of native freshwater biota, including fish, amphibians and invertebrates. As well as vertebrate invaders, invasive insects such as social Hymenoptera are almost certainly severe threats to many native insects, but their impacts are not fully documented and some continue to be debated. In general, losses of native insects are thought to be substantial – but generally not documented, so that insect conservation has involved much basic investigation as a prelude to defining and designing management. Much of the discipline's development has involved the effective transition from perception of need, through focused data accumulation, to practical management and protection, whether of ecosystems, communities or individual species or subspecies. Several early entomologists commented on needs for habitat protection in Australia, although not directly referring to insect conservation. McKeown (1949) concluded his farsighted book with a short chapter ‘A note on conservation’ that included an eloquent plea for faunal reserves. Day (1965), in calling for retention of reference areas within agricultural production environments, was also amongst the first to warn of overuse of pesticides to combat insect pests. In the widespread absence of detailed case-based evidence for losses of native insects, much of conservation necessarily relies on such general ameliorative measures and protection of remaining natural environments, particularly on protection of remnant habitats in highly altered landscapes.

Whilst one of us was preparing the first overview of insect conservation in Australia (New 1984), four of the leading publishers in Australia were approached to probe possible interests in producing the book. It was eventually published in Europe. At that time, few people in Australia were truly concerned about the fate of the massive number of endemic insects, and no commercially-viable readership for such a book was evident. The only Australian publication cited by Pyle et al. (1981), a review of insect conservation status (Key 1978), contrasted markedly with more than 120 references on northern hemisphere insects in that pioneering review. Key knew of no Australian mainland insect that was conclusively extinct, and considered few species seriously threatened with extinction. The species he noted under threat were restricted to Odonata and Orthoptera – but Key commented also that knowledge for others was unavailable to determine that species were threatened or have become extinct. He also emphasised the vulnerability of island insects, noting the putative extinction of the Lord Howe Island stick insect (*Dryococelus australis*, Fig. 9.1) from predation by introduced rats. By the mid-1970s it was becoming recognized increasingly that the most threatened insect species were likely to be those frequenting specialised habitats such as native grasslands, heaths and marshes (Matthews 1976) and unable to persist in the culture steppe environments resulting from anthropogenic change. Specific mention of morabine grasshoppers in both the above accounts reflected that some of these wingless Orthoptera (specifically, species of *Keyacris*) were known only from small, long-enclosed areas such as pioneer cemeteries (within which native grasses and herbs persisted long after they were eradicated by grazing from the surrounding landscape) and that some populations contained only a few dozen individuals. Such small areas, including rail reserves and similar protected enclaves, were acknowledged as needing strenuous protection.

Nevertheless, the major natural history book on Australian insects from the 1970s (Hughes 1974) made no mention of conservation, and the term is not included in its index. The first edition of the major text ‘The Insects of Australia’ (Mackerras 1970), likewise, omitted the topic. On a somewhat broader level, invertebrates were largely ignored or not treated in several local books that stimulated much general conservation awareness and interest: as examples, Serventy’s (1966) call for conservation mentioned insects only as exotic introductions, and Frankenberg’s (1971) review of nature conservation in Victoria was restricted to vertebrates and plants. Both Marshall (1966) and Frith (1973) also largely treated ‘animals’ or ‘wildlife’ as vertebrates alone. Nevertheless these books, and others, laid the foundation of practical

Fig. 9.1 The Lord Howe Island stick insect, *Dryococelis australis*, was long feared exterminated by rats and, a tiny population was discovered on the remote and steep Ball's Pyramid, near Lord Howe Island (Priddel et al. 2003), leading to a major exercise to try to breed the insect in captivity. Leadership from a dedicated team at the Melbourne Zoo, and commencing with a single pair of adults has led to rearing of hundreds of insects, with plans to release the species to the wild as suitable rat-free sites become available. This notable captive-breeding exercise is described by Honan (2008) (Photo: Patrick Honan)

conservation need in Australia through demonstrating the parlous state even of many well-known vertebrates and the needs for greater representation of habitats in reserves and effective protection of species and ecosystems. Insects and their relatives were thus largely passengers in these early endeavours, but undoubtedly benefitted from being 'under the vertebrate umbrella' of increased impetus to reserve and conserve natural habitats. Indeed, there is little evidence of any concerted 'conservation movement' in Australia before the 1960s, when books such as those mentioned above appeared. From that perspective, conservation interest in insects has not in fact lagged far behind that for much more popular animals. Eloquent pleas for conservation of insects and other invertebrates were included by Douglas (1980) in demonstrating many aspects of wider conservation need for Western Australia.

An essay by Marks (1969) was thereby far ahead of its time, in being the first major call for invertebrate conservation in Australia, and discussing a varied suite of taxa that were unusual elements of the fauna and that were considered worthy of such effort. They also represented a variety of different ecosystems threatened by people. This essay was included in a broadly ranging book that has become one of the classics in Australia's conservation literature, and the three basic requirements nominated by Marks would be accepted readily today: (1) clear statements of facts on which to base conservation action (with a comment that many invertebrate zoologists 'must first be stirred out of their defeatist attitude that no one will be interested'!); (2) a central clearing house to gather, collate and disseminate this information to both government and private bodies concerned about conservation; and (3) increased public interest and goodwill toward invertebrates. She also called for effective protection of reserves, for example from grazing.

Support for insect conservation appears to have arisen in different interest groups at different times, and in different guises.

(a) Field naturalists initially led the conservation debate. For example, the Field Naturalists Club of Victoria, established in 1880, was a leader in the establishment of conservation reserves. While it did not specifically support insect conservation in its early days, information on invertebrates gathered by both professional scientists and amateur naturalists was published in its journal, *The Victorian Naturalist*. Special issues of this journal dedicated to invertebrate conservation were published in 1995 and 2008.
(b) Entomologists. It is fair to comment that much of the impetus for insect conservation interest has arisen from the professional entomologist sector. The various government conservation agencies did not employ entomologists until relatively recently, and until the last few decades, most government entomologists were either museum-based or applied entomologists, concerned primarily with either agricultural or forest pest suppression. Some museum-based insect curators were active in promoting insect conservation because they had knowledge about the taxonomy, biology and distribution of many insect groups, and concerns over the future of the fauna. One notable early example is the Entomological Society of Queensland's (ESQ 1974) report on conservation of Cape York, the northeastern tip of Australia, a major region of transition between the faunas of New Guinea and Australia and harbouring tropical rainforest with an enormous endemic insect fauna subject to losses through vegetation clearing.
(c) Academics. Individual academics have been responsible for the promotion of insect conservation arising from particular environmental issues (such as the flooding of Lake Pedder, in Tasmania, below).
(d) Establishment conservation organisations (such as the Australian Conservation Foundation and the Victorian National Parks Association) have historically played only minor roles in promoting insect conservation as a distinct theme.
(e) Government conservation agencies. Until the 1980s, government conservation agencies provided little or no encouragement to protect insects. This was partly determined by legislation. In some States, insects were, by implication, all categorised as pests unless proven otherwise. In Victoria, protective legislation only applied to "wildlife" which only included vertebrates (but not fish, which were covered under the commercially orientated Fisheries Act). The Wildlife Act was based on exploitation of wildlife. Until the passing of the *Flora and Fauna Guarantee Act* in Victoria, any attempt to protect any species of insect would have required the passing of legislation in parliament to first declare each species of insect to be considered as "wildlife."

Most of the published literature in Australia on insect conservation involves terrestrial species. However, it is arguable that the highly political campaign associated with flooding of Lake Pedder for hydroelectric purposes in Tasmania in the late 1960s may have been instrumental in putting threatened invertebrates onto wider agendas. Lake (2001) provided a historical description of the fauna species associated with Lake Pedder before flooding and more recently. Although the flooding of Lake Pedder was not reported to have caused the possible extinction of any insect species (with some scientists believing that this may reflect lack of knowledge rather than reality), the plight of the Lake Pedder earthworm (*Hypolimnus pedderensis*) and the Lake Pedder planarian (*Romankenkius pedderensis*) was probably the first attempt to use invertebrates of conservation significance to stop a major development for conservation reasons. At that time the Australian community was not ready to embrace the idea of the need to conserve invertebrates. The important consequence from Lake Pedder is that it stimulated a group of limnologists to undertake research on freshwater invertebrates that included a strong habitat protection focus. Invertebrates became flagships for habitat conservation, and this interest led to establishment of long-term and widespread freshwater monitoring programmes in Victoria. This development coincided with the recognition by governments (both State and Commonwealth) of the importance of good water quality, and the value of aquatic invertebrates as indicators of river health. Significant resources were provided by government and water management authorities to work on the taxonomy, biology and distribution of the major aquatic invertebrate groups, resulting in comprehensive databases for many of the freshwater invertebrate species, including many groups of insects that are now amongst the best-understood insect orders in the south east of Australia. An equivalent effort is lacking for the terrestrial invertebrates, although it has to be acknowledged that the aquatic systems are easier systems in which to undertake such work because they are physically less complex and, commonly, more discrete and limited in extent.

9.2 The Australian Entomological Society

Elizabeth Nesta ('Pat') Marks (Box 9.1, Fig. 9.2) was a pivotal figure in establishing interest in insect conservation, and was a major player in establishing the Australian Entomological Society (AES, the first national entomological society in the country) in 1965. As founding Vice President, she chaired its first executive (Marks and Mackerras 1972). It was entirely fitting, also, that Marks became the first Convenor of the Society's standing Conservation Committee in 1969. That committee comprised a small number of members from around Australia, and was charged with investigating any relevant matters referred from the executive, as well as initiating discussions of matters raised by interested parties, should they be considered important. The initial matters for consideration in 1969 included (1) drafting guidelines for collecting insects in National Parks; (2) investigating possibilities for reservation of certain alpine insect habitats in New South Wales; and (3) aerial spraying for

Box 9.1

Dr Elizabeth Nesta Marks (28 April 1918–25 October 2002). 'Pat' Marks, her universal nickname flowing (as 'Patricia') from her baptism in St Patrick's Cathedral, Dublin, as her Australian–born parents were based in that city at the time of her birth, was a distinguished entomologist who gained an international reputation for her lifelong work on mosquito taxonomy. Her working career was largely based within the Brisbane area, but she undertook field work in New Guinea and elsewhere in the Pacific. She was an imposing person, described in a tribute by her relative Margaret Ward as 'a woman who was generous, formidable, inquisitive, rigorous in her work and a defender of family history and tradition'. Her commitment to conservation and related community issues reflected these characteristics: Tim New met her first in 1971 and corresponded frequently over insect conservation issues over the next decade or so, with substantial benefits coming from her considered comments. She was a foundation member of the Australian Conservation Foundation (from 1966) and, more than any other individual, paved the way for invertebrate conservation in Australia. Pat was an avid historian and wrote the important 'Biographical history' chapter in 'The Insects of Australia' (Marks 1991) in which, characteristically, her own contributions are minimised. A lifelong entomological enthusiast, she believed her interests to commence with a 1927 Queensland Naturalists' Club outing.

Many aspects of her life and work are included in a memorial issue of the Australian Entomologist (2006), from which some of these notes are derived and in which the photograph reproduced here was the frontispiece.

mosquitos around Brisbane – a topic of considerable earlier interest within the Entomological Society of Queensland. Marks, herself a leading mosquito taxonomist, was an ideal advocate: as Monteith (2006) wrote in a tribute 'She was a woman of imposing presence and strong personality, with a sense of obligation to her science and to the community in a broader context'.

The agenda thus tended to be political in emphasis, and helped to bring a national perspective to some more local issues, rather than initiating more general agendas such as biodiversity surveys, or focusing on single taxa. The Committee's first national exposure was through a submission prepared by Marks to the House of Representatives Select Committee Inquiry into Wildlife Conservation. The resulting wide-ranging report (1972) from the Inquiry, to which about 600 submissions were made, included no direct reference to insects. A second, similar, exercise some years later was a Society submission to the Senate Inquiry into 'The impact on the Australian environment of the current woodchip industry program', prompted by widespread concern over forest clearfelling (upon which controls seemed minimal) for export of wood chips to Japan. The Conservation Committee's submission (New 1976) was

Fig. 9.2 Elizabeth Nesta Marks (1918–2002) (Photo: courtesy of the Australian Entomologist)

supplemented by individual submissions from J.R.J. French, P.S. Lake and R.W. Taylor, so that considerable information on the ecological roles and importance of insects in Australian forests was made available to the six-member Senate Standing Committee. Amongst other topics, the AES Committee urged a multidisciplinary review of forestry practices and impacts, retention of areas of special ecological or other scientific interest (as reservoir habitats, adequately buffered against nearby disturbance), and controls over rotation periods and sizes of coupes. Specific guidelines for planning clearfelling, regeneration and mosaic felling were suggested. Taylor's aim was to convey the importance of lack of capability even to document the extent of Australia's insect fauna in the areas to be exploited, and the need to do this in order to clarify and support inferences of the effects of clearfelling and other forestry practices. His submission (Taylor 1976) introduced the term 'taxonomic impediment', since then employed widely to convey difficulties of documenting insect assemblages, and which he developed further several years later (Taylor 1983). Because of the importance of the term in more recent discussions of insect diversity, his original wording is given here (Senate Hansard 1976: 3724): (1) ' … ecological investigations are often seriously impeded by the lack of an adequate taxonomic system …'; and (2) ' … our need to break the existing taxonomic impediment to progress in broad synecological studies, which we need urgently to pursue, if we are to understand, anticipate, evaluate and monitor the effects of forestry and other land use practices upon the flora and fauna with which we share this continent..'. The term was thus coined in the specific context of ecological interpretation for conservation management. However, with widespread realisation that full descriptive appraisal of the rich insect fauna cannot precede strenuous conservation, the concept has only limited relevance in modern conservation perspective, in which topics such as the functional ecological importance of insects are more persuasive to action.

Successive Convenors of the AES Conservation Committee are E.N. Marks (1969–1972), B.Y. Main (1972–1975), T.R. New (1975–1987), P. Greenslade (1987–1991), L. Hill (1992–1994), A. Wells (1994–1995), J.D. Majer (1995–2002), R.V. Gunning (2002–date). The committee has continued to hold a 'watching brief' on many matters of interest, and members have contributed individually to advancing insect conservation. Within the States, the Entomological Society of Queensland and Entomological Society of Victoria, have both contributed to widening interest in insect conservation over many years. The AES held its first major workshop on invertebrate conservation in Perth in August 1987 (Majer 1987), with presenters discussing a variety of general themes and case scenarios addressing practical and interpretative problems. Although several contributors discussed particular groups of invertebrates (such as ants, aquatic insects, chironomids, beetles and spiders) no papers dealt with conservation of individual species. From that time on, however, contributed papers on insect conservation have appeared more frequently at AES scientific meetings.

The early progress summarised above has two rather unusual features. First, the main initial concerns have largely been on impacts of threatening processes and general aspects of insect conservation, rather than arising almost solely from the plight of single species. Second, a primary focus on butterflies was not a dominating initial driver for progress. The first of these continued with the AES submission to the National Conservation Strategy Conference (New 1983), enlarging on the consequences of the taxonomic impediment and calling, inter al., for (1) further research into guild and community structure; (2) establishment of insect distribution recording schemes; (3) extensive or total reservation of some rare vegetation types; (4) acknowledgment that many insect species are at risk from localised habitat destruction; and (5) needs for detailed ecological studies in which to found habitat management for insects. The full historical impacts of the major changes to Australian environments in the century following European settlement may never be known. Those changes, by analogy with modern interpretation major threats to insects, range from large scale land clearing and wetland flow regimes, to the impacts of alien animals and plants introduced or permitted to persist with little attention to the consequences.

9.3 Single Species Focus

The importance of single species issues in insect conservation came to the fore with two major contributions focusing on this level: the IUCN Invertebrate Red Data Book (Wells et al. 1983), and a report prepared through AES for the Australian

Fig. 9.3 The Ancient greenling, *Hemiphlebia mirabilis*, an intriguing 'living fossil' damselfly long feared extinct but now known from several swampy localities in eastern Tasmania, southern Victoria and far south eastern South Australia. One of many notable Australian endemic freshwater insects, one of the first of these listed formally as threatened, and an important flagship for aquatic insect conservation (Photo: T.R. New)

National Parks and Wildlife Service (Hill and Michaelis 1988). Both documents listed examples of insects of major conservation interest or which were regarded as threatened – the first as a few examples, and the second as a broader national survey, but neither comprehensive. Nine Australian insects were specifically treated by Wells et al. (1983), representing the orders Ephemeroptera (1 species), Odonata (1), Orthoptera (1), Plecoptera (3), Diptera (2), Hymenoptera (1) – probably the only time that stoneflies have predominated in any such list and Lepidoptera were absent! These international profiles were of species recognised as globally significant or of exceptional evolutionary interest, and some had already been promoted widely for conservation. Some were putative living fossils: the damselfly *Hemiphlebia mirabilis* (Fig. 9.3, amongst the major priorities of the IUCN Species Survival Commission Odonata Specialist Group) and the 'Dinosaur ant', *Nothomyrmecia macrops*. As a remarkable Australian endemic and one of the most primitive living ants this species came to be regarded as the 'holy grail' of myrmecology and, despite no evidence of its current existence in the State, was listed as protected in Western Australia. Its rediscovery in South Australia in 1977 (Taylor 1988), prompted considerable research into its biology but, despite considerable subsequent survey, it has still been reported only from a limited area of that State. Others are unusual narrow range endemics threatened by habitat diminution (flightless stoneflies) or water quality (mayflies, torrent midges), and the stick insect *Dryococelus australis* (Fig. 9.1) was considered likely to have been exterminated. Several of these taxa have remained important international flagships for insect conservation; but others have scarcely been studied in the intervening years. The Hill and Michaelis (1988)

Table 9.1 Early perspective: the seven main priorities for advancing insect conservation in Australia suggested by New (1984)

1. A broad education programme to emphasise the importance of insects
2. Increasing consideration, perhaps through legislation, of environmental changes on insects, together with monitoring impacts
3. Detecting and listing insect species and groups (such as endemic radiations) that merit priority consideration for conservation, perhaps as the basis for a local Red Data Book or similar directory
4. Accelerate progress toward comprehensive habitat representation in reserves, including establishment of specific reserves for insects
5. Increase funding and other support for production of field guides and synoptic works on Australian insects
6. Progressively, fund autecological studies of more notable species as basis for conservation management
7. Recognition that simply 'listing' a species is not alone sufficient for conservation, and that prohibition of take, unless justified soundly, may also have harmful effects

survey was based on a survey of the 610 Australia-based members of AES, from whom 54 responses were received to requests to suggest threatened species and the reasons for concerns. It revealed very mixed attitudes toward worth and practicality of considering individual insect species in such a vast and poorly-documented fauna. In addition to the taxonomic impediment, the 'ecological impediment' (whereby the distribution and ecology of most insect species is almost wholly unknown or inferential) and the paucity of individuals of many species in even the largest institutional collections suggested need for considerable caution in evaluating conservation status. Considerable suspicion persists that, for many taxa, simple lack of information contributes to inflated threat status. Formal designation of taxa as threatened is accompanied in several key Acts by the provision to 'de-list' them, should additional information reveal that they are indeed secure. Uncertainties are understandably least for the better-studied insect groups, and 72 Lepidoptera (61 of them butterflies) were the largest group of the 260 insects and other arthropods named in responses. Many of the butterflies have since proven to be in genuine need of conservation. Interpretation remains more difficult for the other large component of the list, Drosophilidae, comprising 56 of the 63 Diptera proposed and reflecting submission from a single concerned specialist. Most of the species are from wet forests in the tropics or subtropics, and many are known from few localities or individuals and may be vulnerable to habitat changes. The embracing conservation need may simply be reservation of adequate samples of such forests. However, whilst this extensive listing might indeed reflect a genuine conservation need, it also gives a probably misleading impression for needs of other Diptera: simply that no-one gave a similar response for any of the other 90 or so families represented in Australia does not mean that they are 'safe'. Collectively, this survey revealed considerable concern for individual insect species across many orders, and the variety of threats to them. The survey generally endorsed the seven main priorities for advancing Australian insect conservation suggested by New (1984) (Table 9.1), with education and accelerated declaration of suitable reserves needing particular, urgent attention.

Table 9.2 Current (August 2010) Australian legislation under which insect taxa may be listed for protection

Act	No of insects listed	
	Orders	Species
Commonwealth		
Environment Protection and Biodiversity Conservation Act 1999	3	8
State/Territory		
Threatened Species Conservation Act 1995 (NSW)	5	10
Flora and Fauna Guarantee Act 1988 (Vic)	7	36
Nature Conservation Act 1992 (Qld)	1	7
National Parks and Wildlife Act 1972 (SA)		(none)
Wildlife Conservation Act 1950 (WA)	2	5
Threatened Species Protection Act 1995 (Tas)	4	39
Nature Conservation Act 1980 (ACT)	1	1
Territory Parks and Wildlife Conservation Act 2000 (NT)	1	4

Increased efforts for invertebrate taxonomy were also a priority. Continuing studies on selected species on such lists, latterly those passed into legislation as designated 'threatened species', have been instrumental in communicating the variety of invertebrate life forms and ecology to non-biologists.

From the 1980s, in particular, focus on species became more widespread, and paralleled increasing development of legal instruments for conservation at the twin levels of State/Territory and Commonwealth. Entomologists, of course, were concerned that insects should not be overlooked in developing schedules of protected or threatened species likely to receive conservation priority: nevertheless, the more traditional approaches to conservation in Australia tended to render their presence on such lists dominated by better-appreciated vertebrates rather tokenistic. The current legislation affecting insect listings are summarised in Table 9.2. The numbers of insect taxa listed remain small, but the process of formal nomination and evidence-gathering for listing provides the best available ground work for any management needed. There is considerable overlap with the Hill and Michaelis (1988) advisory listings, reflecting that information on many of those taxa was more readily available for preparing for formal status evaluation as legal opportunity to do this arose, and that some had long been of concern with some consensus over their need. However, the process of 'listing' insects, particularly butterflies, for protection received very mixed welcomes, and led to strenuous and sometimes emotional debate over the consequences of 'prohibition of take', with tensions over the restriction of hobbyist interests and activities by both trade of specimens (summary by Monteith 1987), and wider conservation effects (see below). Through such listings, butterflies became increasingly important foci for species conservation but paucity of historical documentation, especially in comparison with parts of the northern temperate regions, was not appreciated by many 'politicians' who tended to confuse 'lack of information' with 'lack of importance or interest', because fully definitive information on distribution or ecology was not available. This gap was brought home forcefully in an initial compilation of butterfly distribution records in Victoria, perhaps the most intensively surveyed region of mainland Australia at the time, which showed that many 10 × 10 min areas of the State had no butterflies reported from them, and that the major highways and cities were easily detectable on such maps as concentrations of collector activity (ESV 1986). There was thus considerable impetus to both (1) convey the dimensions of the problems of insect documentation and (2) convince that the conservation needs were genuine and founded in fact, rather than under-documentation. The considerable interest in butterfly conservation elsewhere in the world has facilitated Australian conservation interest as deserving examples have been found. In common with other insect orders, regional or narrow range endemism is common, so that some butterflies have been promoted as local flagships (New 2010). Some conservation programmes are accompanied by considerable education efforts to increase awareness of conservation need amongst young people. Most effort has focused on members of three highly characteristic Australian radiations within the Hesperiidae (Trapezitinae), Nymphalidae (Satyrinae) and Lycaenidae. Many species and subspecies have declined considerably in range and abundance but no full species of butterfly in Australia is known to have become extinct. Many, however, are threatened. As for some other insect groups (Odonata: Watson 1982; Orthoptera: Rentz 1994) the major threats to the group could be specified in broad terms but more specific context threats had not been defined. Honing threat assessment and abatement from the general to the more site-focused or taxon-specific needs is a core element of increased understanding.

The haste to apply conservation status from firm criteria of threat such as Critically Endangered and others based on IUCN Red List categories of threat in the absence of adequate information may result in political difficulties for insect conservation in the poorly documented Australian fauna. For example, giving the Golden Sun-moth (*Synemon plana*, Castniidae) the highest National listing possible and the Bathurst Copper butterfly (*Paralucia spinifera*, Lycaenidae) the highest listing possible in New South Wales may have reduced the value of these species as flagships, because many more populations have been found since they were listed, and their status is increasingly difficult to justify. A more cautious approach was adopted in Victoria where taxa are only given a broader Threatened status if they are listed, and delisting a taxon on the basis of new information is relatively easy (and has been done for several listed taxa).

9.4 Wider Focus

Conceptual and practical logistic barriers to pursuing insect conservation solely on an individual species basis has led to considerations of the wider benefits that may flow from these, and wider arenas through which insects may be conserved through protection of their habitats, or be tools for conservation advocacy.

The entities eligible for listing under the Victorian *Flora and Fauna Guarantee Act 1988* include the category of 'Threatened Communities', one of which is designated 'Butterfly Community No. 1'. This designation led to considerable discussion over how such entities may be characterised unambiguously, and the extent of difference needed to separate 'community' from simply 'site' or 'specific place'. Thus, Butterfly Community No. 1 was raised for the Lepidoptera assemblage at Mt Piper, Victoria with the particular significance of the joint occurrence there of two species of *Acrodipsas* (ant-blues, Lycaenidae) and several other scarce species of conservation interest, and represented mainly by hill-topping records (Britton et al. 1995). The problem of community distinctiveness arose with later surveys at other sites, in which some, but not all of those taxa were recorded (Wainer and Yen 2000), and was confounded further by 'Mt Piper' becoming one of the 30 invertebrate sites nominated specifically for listing under Australia's then active National Estate Register (Greenslade 1994) to draw attention to site features – rather than just the species occurring there. Background to this complex issue is summarised by New (2010).

Importance of habitat/site features leads to implications of wider conservation significance. The attention drawn to hill-topping assemblages at Mt Piper was followed by clearing hilltops becoming a listed Threatening Process under New South Wales legislation. In another context, recent conservation studies of the Golden Sun-moth (*Synemon plana*, Castniidae) on the south east mainland (see Clarke 2001 for background) have elevated it to a widely-regarded flagship species for conservation of endangered lowland native grasslands. It is ranked with two reptiles as an ambassador for these formerly extensive areas, already reduced to tiny remnants of their former extent and under considerable pressure for further urban and industrial development.

9.5 Spreading the Word

Needs for effective penetration of the then overtly vertebrocentric conservation orientation on Australia led to attempts to promote invertebrate conservation in primarily non-invertebrate symposia and meetings. Thus, in Victoria a trio of threatened taxa, a butterfly (the Eltham Copper, *Paralucia pyrodiscus lucida*, Fig. 9.4), a damselfly (the Hemiphlebia damselfly or Ancient Greenling, *Hemiphlebia mirabilis*), and an earthworm, (the Giant Gippsland earthworm, *Megascolides australis*) were compared and contrasted to display the ecological variety of invertebrates and their conservation needs (Yen et al. 1990) at a meeting on population dynamics and conservation attended primarily by devotees of bandicoots. Further influence was attempted through a federal initiative in which the Council of Nature Conservation Ministers issued the Australian Statement on Invertebrates (ConCom 1989, modeled on the European Charter for Invertebrates), in which the ten main themes listed in Table 9.3 were expanded and exemplified in a concise and readable document which contained a strong call for conservation and concluded with the sentence 'No animal or plant species should be allowed to disappear because of humanity's

Fig. 9.4 The Eltham Copper butterfly, *Paralucia pyrodiscus lucida*, one of many endemic myrmecophilous Lycaenidae in Australia, is perhaps the most important insect through which conservation awareness has been promoted in urban environments. Small remnant sites surrounded by housing in outer north-east Melbourne, Victoria, became Australia's first dedicated butterfly reserves, and aroused massive public interest (Braby et al. 1999). As with the campaign for the Richmond Birdwing (*Ornithoptera richmondia*) in Queensland and New South Wales, it is the focus of a long-running conservation campaign with considerable community support and involvement pivotal to continuing success (Photo: A.L. Yen)

Table 9.3 The main paragraph headings of the Australian Statement on Invertebrates (ConCom 1989)

1.	Invertebrates are the largest component of our fauna, both in number of species and biomass
2.	Invertebrates are an important source of food for other animals
3.	Invertebrates may also constitute a source of food for mankind
4.	Invertebrates are vital to nutrient recycling and to the fertilization and growth of the vast majority of cultivated plants
5.	Invertebrates are useful in protecting farming, forestry, animal husbandry, human health and water purity
6.	Invertebrates are valuable aids for medicine, industry and crafts
7.	Many invertebrates are attractive
8.	Some invertebrates may harm human activities, but their populations may be controlled naturally by other invertebrates
9.	Mankind can benefit greatly from enhanced knowledge of invertebrates
10.	Terrestrial, aquatic and aerial invertebrates should be protected from possible causes of damage, impairment or destruction

activities.' The Statement attempted to summarise importance of invertebrates in simple, basic and easily appreciated terms.

In the same year, an overview of insect conservation in Australia was presented at what was probably the largest international gathering on insect conservation held up to that time. At that Royal Entomological Society Symposium in London, Greenslade and New (1991) emphasised the variety of important insect biomes in the isolated island continent, and that this variety (spanning wet tropics to cool temperate latitudes, and each with highly characteristic endemic insect complexes) under the control of a single government was unique.

Major advances during the 1990s devolved on increased interest and awareness to substantially augment the number of people working for insect conservation, both in universities and government agencies. The first national meeting of a series on 'Invertebrate biodiversity and conservation' was held at the Queensland Museum, Brisbane, in 1992. The resulting volume of Proceedings (Ingram et al. 1994), together with those from later similar gatherings in Melbourne (Yen and New 1997), Sydney (Ponder and Lunney 1999) and Adelaide (Austin et al. 2003) have lasting value in tracing this maturing expansion of expertise and interest, with progressions from simple characterisation of 'biodiversity' to practical management involving insects as both tools and targets in conservation activities. More recently, such meetings have been held in conjunction with others and, despite continuing interests, similar volumes have not eventuated. In due course, however, interest and experience led to very constructive debates and workshops that have helped clarify unified thinking about many important themes (Cassis 1999). Thus, a workshop reported by Cassis emphasised the three major recommendations of Yen and Butcher (1997, see below) of needs for (1) better education on importance of invertebrates and their conservation; (2) increased scientific knowledge and understanding; and (3) an adequate funding programme. Coordination of scientific interests has also been facilitated by other means: Tasmania's Invertebrate Newsletter ('Invertebrata'), for example, has been produced since 1994.

The national conservation agency, under various name changes and incarnations, sponsored several key documents on insect conservation in the 1990s and early 2000s. By far the most significant is a national overview of conservation status and needs of Australia's non-marine invertebrates, in which Yen and Butcher (1997) placed the situation for Australia into a broad international perspective and accumulated much of the previously highly scattered information into a single major synthesis. It remains indispensable to anyone seeking information available to that time. It was paralleled by a similar review for marine invertebrates (Ponder et al. 2002), the two compendia comprising a near-complete survey of conservation progress for these major faunal components and revealing the possible ways forward. Over this period, also, most of Australia's major vertebrate groups had been treated in national 'Action Plans', in which species-level appraisals of conservation status and needs were summarised as compendia for conservation progress and setting priorities. Despite interest in doing so, most insect groups did not lend themselves well to this approach but, following from an earlier review of butterfly conservation needs (Dunn et al. 1994), reflecting the status of butterflies as the best documented insect group for this purpose, an Action Plan for Australian Butterflies was prepared by Sands and New (2002). The process of wide consultation and information-gathering underpinning this plan was particularly important. A series of eight weekend workshops throughout the country were collectively attended by many of the leading and most informed hobbyists, agency personnel, and other interested people, so that the information obtained by far exceeded that available in published reports and, in many cases, allowed hyperbole to be separated clearly from evidence in allocating conservation status. They also provided opportunity to discuss and evaluate concerns over collecting restrictions and prohibitions, the listing process and its consequences, permit needs and accountability, and improving communication between hobbyists/scientists and managers toward the common needs for conservation. The Butterfly Action Plan (BAP) remains the only such formal appraisal of any natural group of insects in Australia, although Hawking (1999) had informally categorised species of Odonata to indicate three main concerns: (1) the large number of species believed to be endangered; (2) the large number of priority species; and (3) the lack of sufficient information to make reliable assessments for many taxa. The BAP was complemented by similar documentation of a selected example series of 25 other invertebrates, 17 of them insects (Clarke and Spier-Ashcroft 2003). These were selected from a much longer list of more than 800 taxa signaled as of conservation interest, and some had already been listed for protection. The final selection was designed to display the range of groups, habitats and distributions – so, the variety of taxa and contexts of conservation concern – but Clarke & Spier-Ashcroft emphasised that these were simply examples of the much wider needs amongst Australia's invertebrates. One realisation emphasised from this publication was that future insect conservation efforts must largely be based at group or landscape/biotope levels, simply because of the high costs of individual species programmes and difficulties of setting priorities for the very limited support available. Even for butterflies, taxon triage is inevitable with current levels of finance and expertise, and the most enduring and successful programmes continue to rely heavily on volunteer helpers and community interest.

A major education emphasis has done much to capture public interest, not least over the relative novelty of conserving insects, to foster such wider support in species programmes, and to emphasise the intricacies of resource, habitat and individual species management in practice. Community interest and support is a vital component of insect conservation in Australia, perhaps particularly for individual species, to which people in its neighbourhood can relate easily. Some long-running programmes, such as those for the spectacular Richmond Birdwing butterfly (*Ornithoptera richmondia*) in southern Queensland and northern New South Wales (Sands et al. 1997; Sands 2008) and Eltham Copper butterfly (*Paralucia pyrodiscus lucida*) in Victoria (Canzano et al. 2007; New 2010), both now operating for more than 20 years, have depended very substantially on collaboration with local people, including school children. The Eltham Copper case had wider importance in several ways: (1) it was the first butterfly for which dedicated reserves were designated and purchased, as small urban remnants in outer Melbourne (Victoria); and (2) the disjunct nature of populations demonstrated geographical variability in phenology, and threat, so that (3) regional and national conservation priorities differ somewhat and necessitate largely site-specific management. The intensity of management in both these cases has helped to reinforce the realisation that insect conservation is not necessarily a cheap or 'one-off' exercise but one that demands continuing effort and commitment.

Documentation of Australia's insect fauna is still very incomplete and, as elsewhere, lack of taxonomic capability to remedy this is a serious concern. However, the increasing recognition of the importance of insect (and more widely, invertebrate) conservation is gradually laying a stronger foundation for their wellbeing in the future. Many imponderables persist, but recognition of the great variety of insects present, the intricacies of their biology, their central roles in sustaining ecological processes and systems, and their vulnerabilities to imposed change, are aiding calls for the importance of their conservation, by whatever means are available to achieve this.

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Chapter 10
Insect Conservation in New Zealand: An Historical Perspective

Corinne Watts, Ian Stringer, and George Gibbs

10.1 Introduction

The exciting prospect of discovering New Zealand's untapped insect fauna was incentive enough for the early collectors of natural history specimens. Investigation of the fauna began with Joseph Banks on the *Endeavour* in 1769 and was continued by a devoted group of eighteenth century naturalists who occasionally voiced their concern at the rate of destruction and modification of the indigenous ecosystems as European Imperialism fuelled the development of agriculture for the economic base of the new colony. Although records are sparse, at least two early entomologists expressed their opinions in the early twentieth century. G.V. Hudson aired his concern about the dwindling numbers of native insects in a Presidential Address to the Wellington Philosophical Society (Hudson 1900) and later recollected that: 'every summer throughout the "eighties" great fires raged on the hills around Wellington and the air was thick with smoke for days together'. The concept of preserving native fauna was then in the minds of very few and those who protested at the reckless destruction of the forest were regarded as "cranks" …' (Hudson 1950, pp. 161–162). Back 'home' in Britain, another entomologist, Commander James J. Walker (1921) in his presidential address to the Entomological Society of London, also drew attention to the potential plight of New Zealand's insect fauna when, after discussing the rich and endemic attributes of the flora that were being lost both to

C. Watts (✉)
Landcare Research,
Private Bag 3127, Hamilton, New Zealand
e-mail: wattsc@landcareresearch.co.nz

I. Stringer
Department of Conservation, Science & Research,
P.O. Box 10420, Wellington, New Zealand

G. Gibbs
School of Biological Sciences, Victoria University,
P.O. Box 600, Wellington, New Zealand

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agriculture and weed invasion, he said that 'the disastrous effect on all forms of life of this destruction and replacement … (necessitate) immediate and thorough research in what still remains of the endemic animal life of New Zealand, before many of its most interesting forms are lost forever.' However, nothing was done and no consideration was given to the need to conserve invertebrates. Instead, it was the ornithologists who paved the way for the first conservation ethic as they focussed on New Zealand's unusual and dominant bird life. This began with the influential politician, Thomas Potts, who raised awareness for conservation in the 1850s and was eventually in part responsible for the declaration of island reserves for Resolution, Secretary, Little Barrier, and Kapiti islands, gazetted between 1891 and 1897 (Young 2004). Conservation action on behalf of invertebrates did not occur despite increasing knowledge of their uniqueness and significance in understanding southern biogeography issues (Gibbs 2006).

Box 10.1 George Vernon Hudson (1867–1946)

When, at the age of 14, George Hudson set foot in New Zealand, his life's ambition was clearly mapped out. The sixth child of Charles Hudson, a London stained glass window artist, he took up painting insects and writing about them at the age of 11 and never deviated from this. His formative years were watched over lovingly by his father, but never devoted to intensive schooling, and he did not continue with his education once in New Zealand. With so many hitherto unknown insects in the new colony and the prospect of watching while lowland forests succumbed to axes and fire, it is not surprising that George developed an awareness of conservation. His personal experiences included travelling through the 'vast primeval forests of the Manawatu Plains' to get to Palmerston North, and witnessing the smoke rising from the bare hillsides of Makara, to the west of his home in Karori, Wellington. He was well known as one who never hesitated to show his displeasure at the way the Government was conducting the affairs of the country, especially in relation to science and the education system, so the adoption of outspoken views against forest destruction in his lectures and writings was true to character.

George Hudson (Fig. 10.1) devoted his working life to the New Zealand Post Office, reserving his leisure time for entomology, which was pursued with great zeal. He collected specimens whenever he could, built up a huge and meticulous insect collection, and wrote seven illustrated volumes on New Zealand fauna. He was also interested in astronomy and was the first proponent of 'daylight saving time'. He served as President of the Wellington Philosophical Society and played an active role in Wellington science. The only travel outside New Zealand he undertook was an expedition to the Auckland Islands in 1907. GV Hudson is remembered as an author of luxurious insect books that have become collectors' items, yet are still often the only available works on certain insect groups. His call for conservation fell largely on deaf ears at the time, but was undoubtedly very true to his sincere appreciation of the

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Box 10.1 (continued)

Fig. 10.1 George Vernon Hudson, 1867–1946 (S. P. Andrew Studio, Wellington)

natural world and the necessity for understanding how it worked if mankind was to progress in harmony with nature.

It was not until May 1986 that wide attention was first focused on insect conservation in New Zealand. This occurred when the Entomological Society of New Zealand included a special Conservation Symposium in its annual conference at Victoria University (Anon. 1987). Included were invited speakers on the past and present role of the society in insect conservation (Russell 1986), 'guidelines for selecting and maintaining insect faunas' (White 1986), 'the status of rare and endangered species' (Scott and Emberson 1986) and some implications of biological control practices (Roberts 1986). One stimulus for this meeting was the announcement, in 1985, of the intention to create a Department of Conservation (DOC), which came into existence on 1 April 1987, formed largely from components of the former NZ Wildlife Service, the NZ Forest Service and the Department of Lands and Survey (Anon. 1995).

This chapter reviews the role of organisations, individuals, and the insects themselves as insect conservation has developed to become a significant component of the conservation movement in New Zealand. We first provide a wider perspective in relation to settlement by humans. This is summarised from the viewpoint of what threats the insects were subjected to and what still threatens them. Protection of insects commenced – indirectly – with preservation of habitat through the legal protection of land and creation of island sanctuaries. Although not intended, this had major benefits for the insect fauna. The brief outline of the rapid habitat changes that occurred after human settlement and of land reservation are drawn largely from *Environmental histories of New Zealand* (Pawson and Brooking 2002) and *Our islands, ourselves* (Young 2004).

10.2 First Steps

Assembling museum collections of insects was the first step towards appreciating the extent of the fauna. Although a number of early naturalists devoted their lives to the accumulation and description of species of New Zealand insects, many of the insects collected went to overseas museums, where they remain difficult to access for researchers working in New Zealand, creating lasting problems for taxonomists(Watt 1970).

Although the study of insects in New Zealand has a long history, with early collectors of most groups making substantial contributions towards an understanding of the fauna, signs of a conservation policy targeted at insect species or populations were, with a few notable exceptions, slow to emerge. Foremost among the exceptions was G.V. Hudson (Box 10.1), a Wellingtonian devoted to writing illustrated insect books for the public (e.g. Hudson 1892, 1904, 1928, 1934), whose expressions of concern for the destruction of insect habitats are cited above. By the early 1970s, conservation awareness was stirring among some entomologists, particularly Graeme Ramsay (Box 10.2) who was influenced by J. T. Salmon, another entomologist who was active in advocating for forest and habitat conservation. Attention was first focused on gathering information for Ramsay and Gardner's Red Data Books (1977) in which the authors stressed the urgent need for conservation measures to ensure the survival of the suite of species that they listed, including 23 large-bodied insect species and 23 terrestrial molluscs. Further concern for large-bodied insect species developed after Ramsay (1978a) presented evidence that rodents may have a considerable deleterious impact on some of them. Ramsay (1978a) also drew attention to the possible impacts of human collectors and the need to establish a 'code for insect collectors' in order to minimise damage to sensitive populations (later republished in Ramsay and Singh 1982). The 1980s marked the beginning of insect conservation awareness around the world, where attempts were being made to bring insect conservation more in line with what was happening with vertebrates. This was exemplified in a state-of-the art review (Pyle et al. 1981), although without any mention of New Zealand. However, in spite of the fact that in 1980 New Zealand produced an Amendment to the Wildlife Act 1953, in which some terrestrial and freshwater invertebrates gained legally protected status under the definition of 'animal', the New Zealand authorities still failed to recognise that, in common with vertebrates, insects could suffer from critical declines and potential extinction, unless remedial actions were taken. A New Zealand Red Data Book (Williams and Given 1981) was produced but failed to include any invertebrates, apparently because the submitters were unable to agree on what should be included (Scott and Emberson 1986). J. Charles Watt, however, listed known examples of the 'most endangered' insect species as: the giant weta *Deinacrida carinata, D. rugosa* (Anostostomatidae), the large flightless click beetles, *Amychus granulatus* and *A. candezei* (Curculionidae), which were all confined to small islands; as well as the mainland species: the wingless chafer beetle, *Prodontria lewisii* (Scarabaeidae) and the Wellington coastal population of a large flightless weevil, *Lyperobius huttoni* (Curculionidae) (Watt 1981). Watt also cited small island populations of a stag beetle, *Dorcus ithaginis* (*Geodorcus ithaginis*) (Lucanidae: Mokohinau Is.), a longhorn beetle, *Xylotoles costatus* (Cerambycidae: Chatham Is.) and another large flightless weevil, *Hadramphus stilbocarpae* (Curculionidae: Big South Cape Is.) as examples of species that had not been seen 'since last century … possibly…extinct'.

Box 10.2 Graeme William Ramsay (1932–)

Graeme Ramsay (Fig. 10.2) was born with an abiding interest in insects and was fortunate to have made it his life's career. While attending Rongotai College in Wellington he used to regularly visit the late Professor Emeritus John T. Salmon at the Dominion Museum, as it was then known. This was towards the end of World War II when the Museum was still occupied by the New Zealand Army and had guards manning its doors. He gained an M.Sc. with First Class Honours and a Ph.D. in Zoology at Victoria University of

Fig. 10.2 Graeme William Ramsay

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Box 10.2 (continued)

Wellington before joining the Entomology Division of the Department of Scientific and Industrial Research in Nelson. Here he became a systematist in the section which eventually became the New Zealand Arthropod Collection (NZAC). His research mainly concerned the Orthoptera and the Acari. In 1968 he was awarded a Nuffield Fellowship which enabled him to study Acari at the then British Museum of Natural History and at the New University of Ulster. He also updated Miller's 1956 'Bibliography of New Zealand Entomology' in collaboration with Trevor Crosby over many years. When this update was eventually published (Ramsay and Crosby 1992) New Zealand became the first country in the World to have such information available about its terrestrial invertebrates listed and therefore available for access. Concomitant with this, the library at the DSIR Research Centre at Mt Albert, Auckland, acquired a copy of every article listed in the bibliography and became in effect the main resource for information about New Zealand terrestrial invertebrates until this resource was split up and moved to various Crown Research Institutes when the DSIR was disestablished. Graeme's final publication with the DSIR was a monograph on the New Zealand mantid fauna.

Graeme developed a longstanding concern and interest in conservation and was involved in preparing the first provisional list of insects which should be considered for legal protection. He also presented a paper at a Wildlife Service Symposium on the effect of rodents in reserves, which drew attention to the serious impact they were probably having on the larger species of our fauna. This was followed by other papers concerned with the collection of insects and proposals and suggestions for their conservation. In 1989, he was invited by the Royal Entomological Society of London to deliver a paper jointly with F.G. Howarth of Hawaii on 'The Conservation of Island Insects and their Habitats' which was duly published (Howarth and Ramsay 1991). In retirement he continues his interest in conservation matters and plans to complete unfinished research.

By 1981, the Entomological Society of New Zealand had set up a Conservation Sub-Committee which actively coordinated and presented submissions on policy guidelines and management plans for Crown-owned areas of Forests and Reserves. In many cases the desired ends were achieved. In 1986, the Society held the 'Insect Conservation Symposium' referred to earlier, which set the scene for a more active interventionist role for this part of the world when faced with declining insect populations.

With the establishment of DOC in 1987, the focus shifted more towards the conservation of individual species for which population decline and recovery management could be defined and ranked in order of priority. The difficulty that has emerged over the past 23 years has been deciding which invertebrate species, of the vast number of potentially deserving ones, should be targeted for conservation effort. DOC took a precautionary approach and this, together with the lack of data (apart from sparse collection records) and the difficulty of stimulating research to obtain it, tended to increase the threat status of the species. Despite the threat status of some insects, it was in general hard to generate interest in insect conservation programmes although there were some notable exceptions, which included beetles, grasshoppers and weta (Orthoptera: Anostostomatidae) that are detailed below. Butterflies are notable for their absence in these examples, partly because of New Zealand's small endemic butterfly fauna (Gibbs 1980) and partly because, with the exception of the naturalised monarch butterfly, the public have been reluctant to take butterflies to their hearts in the way they tend to overseas.

10.3 Threats to Insects

The threats to New Zealand's indigenous vertebrate fauna are well known and well documented. They are habitat destruction, the effects of introducing alien plants and animals on an indigenous fauna and flora that had evolved since the Cretaceous in the virtual absence of terrestrial mammals – only three species of bat were present

Box 10.3 Michael John Meads (1938–2009)

Mike Meads (Fig. 10.3) became a leading figure in invertebrate conservation when his lifelong interest in natural history became his occupation. This occurred after he left farming to become a field technician at the Ecology Division, Department of Scientific and Industrial Research (DSIR) in 1968. There, he developed a science career specialising in invertebrates, while also in his spare time he continued to pursue his other natural history interests, particularly New Zealand lizards. After DISR was disestablished in 1992 he moved to the newly formed Landcare Research and then to Ecological Research Associates of New Zealand before finally forming his own successful computer business.

During his first years in the Ecology Division, Mike undertook invertebrate surveys in the Orongorongo Valley near Wellington. This included a 4-year light-trapping survey of moths. His ingenuity in designing new insect traps such as those for sampling insects on tree trunks and those that sampled insects in the forest canopy are particularly well remembered (Brockie 1992). He also undertook numerous invertebrate surveys in various places, but particularly islands, scattered throughout New Zealand. He was constantly on

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Box 10.3 (continued)

Fig. 10.3 Michael John Meads, 1938–2009 (Photo: Barbara Meads)

the lookout for rare and exciting species – as befitted his nature as a collector: arthropods (much of his collection is now in The Museum of New Zealand/ Te Papa), geckos, stamps, coins, model cars, cacti, orchids and much more were all of interest to him. While in the Ecology Division, he developed a particular interest in the large flightless orthopterans known by their Maori name of weta. This included making the first translocation of a New Zealand insect, for conservation purposes, in 1977 when he successfully introduced a giant weta, *Deinacrida rugosa* (Anostostomatidae), to Maud Island (Te Hoiere). Thirteen years were to pass before the next insect translocation was made for conservation (Sherley et al. 2010). Mike Meads had a passion for invertebrate conservation and wrote strategies for saving the rarest of them. He is perhaps best known to the general public through his popular book 'Forgotten fauna' (Meads 1990), which brought the plight of some of the rarest invertebrates to public attention (abbreviated with additions from Whitaker 2010).

when humans first arrived – and to the attitudes held by the human colonists. Some specimen collectors in the past also had a considerable negative effect. These threats apply equally to insects but these have, in addition, been affected by other less obvious threats such as the introduction of parasitoids, social wasps and ants. Concern has also been raised about the effects of insecticides and other agricultural chemicals, and pollution (Salmon 1973).

10.3.1 Introduced Fauna

Before the arrival of humans, the predators of insects were insectivorous birds, reptiles, freshwater fish, a few species of bats and frogs and other invertebrates. Defense strategies of these insects often included camouflage, freezing behaviour and nocturnal activity that were no defense against introduced mammals that hunt by smell at night (McGuinness 2007). Of these, rats and mice undoubtedly have the greatest direct effect on insects because of the high densities they can reach, although insects are also an important component of the diet of another nine mammalian predators that have become naturalised, including hedgehogs, cats and the mustelids: stoats, weasels and ferrets. The Pacific rat or Kiore (*Rattus exulans*), probably introduced by the first Polyneian settlers, the Maori people, when they arrived in the twelfth or thirteenth century would have been responsible for most of the extinctions caused by mammals (Young 2004). The Europeans who followed began introducing animals, including insects, both unintentionally and intentionally almost immediately after they arrived, starting with James Cook in the eighteenth century (Kleinpaste 1984). The result is that New Zealand now hosts a vast assortment of exotic flora and fauna. Many of the 33 mammals and 36 exotic birds were intentionally introduced by acclimatisation societies aided by the government during the nineteenth and early twentieth century, and some, such as mustelids, which subsequently proved disastrous, were introduced despite vigorous opposition from scientists both in New Zealand and overseas (Hill and Hill 1987). Even the introduced mammalian herbivores affected insects indirectly by the deleterious effects they had on vegetation unadapted for the trampling, rooting, grazing or browsing pressure. Numerous invertebrate predators and parasites were also introduced either deliberately as biological control agents or accidentally and some have directly affected certain native insects or are thought to have done so. Examples include non-specific parasitoids of leaf-roller caterpillars, social wasps and Argentine ants (Roberts 1986). Habitat destruction, however, had a catastrophic effect on the original insect fauna.

10.3.2 Habitat Loss

Before humans arrived, forest extended over 82% of New Zealand and essentially dominated the country below the alpine tree line (Leathwick et al. 2004). Maori burnt a substantial amount that was replaced with scrub, bracken fern (*Pteridium*) and tussock. Most of this destruction occurred to the east of the Southern Alps and in the south of the North Island where rainfall was less than about 800 mm/year. By 1840, when the first European settlers began arriving in substantial numbers, only about 54% of the original forest remained (Cumberland 1941; McGlone 1989; Anderson 2002). Before 1840 Europeans did extract timber from forest around Wellington and Bay of Islands but this was relatively minor in proportion to the overall forest area that had previously been destroyed by Maori. The rate of forest removal accelerated after 1850 and by 1886 forest remained over about a third of the land area: by 1909 it had been reduced to about one quarter of the original area (Starr and Lochhead 2002). Timber extraction continued well into the twentieth century, reaching a maximum in 1907, but most of the forest was destroyed by burning. This was the 'bush-burn' period of Cumberland (1941), between 1875 and 1890, when land 'improvement' by forest clearance was greatest (Wynn 2002; Young 2004). The speed of deforestation was such that some districts became short of wood for building and fuel and, in response, the rate of deforestation decreased after the 1920s as 'a belief in superabundant resources gave way to concerns about rates of exploitation and the possibility of resource exhaustion' (Roche 2002, p. 183). Secondary forest also began regenerating on less economically viable land so that by 1941 about 17% had reverted to forest again (Levy 1949). The result was that the area of farmed land only increased minimally between 1920 and 1960. By the 1970s, 51% of the land area of New Zealand was grassland (Brooking et al. 2002) but prior to this, even the accessible open country – largely created by Maori before Europeans arrived – was 'improved' by pastoralists and farmers who repeatedly burnt it to remove scrub and to stimulate new growth of otherwise unpalatable tussock, and sowed northern hemisphere pasture grasses. Such improved pasture increased from 63,900 ha in 1861 to 6.7×10^6 ha by 1925 (Holland et al. 2002). Such 'pasture is almost a biological desert as far as native New Zealand insects are concerned' except for a few notable exceptions that became economic pests (Watt 1977). Nowadays indigenous forest remains on 29% of the area it once covered (Leathwick et al. 2004): it is still being cleared at a rate of 0.01% per year while indigenous grassland is being destroyed at a rate of 0.14% per year (Ewers et al. 2006). The habitat which suffered the largest reduction in area was freshwater wetlands which declined by 85% from 670,000 ha at the start of European settlement to about 100,000 ha today. This was one of the most dramatic reductions of any habitat in the world (Park 2002). Clearly, such enormous losses of habitats – measured in thousands of square kilometres in the case of forest – resulted in large numbers of insect extinctions (see for example Walker et al. (2004) for a concise explanation of how biodiversity varies with area) details of which must inevitably remain unknown.

10.3.3 Attitudes of European Settlers

Three main attitudes of early European settlers contributed to the slow development of preservation in New Zealand. First, these pioneers were understandably concerned with establishing productive land: forest, swamp and other land covered with 'unproductive' indigenous vegetation were considered waste or wilderness in need of 'improvement'. This attitude persisted well into the twentieth century. Many believed that nothing should stop settlement, and economic arguments, such as preserving scenic attractions to capture the tourist dollar, were usually necessary to preserve 'unimproved' land (Starr and Lochhead 2002). Second, many early settlers desired familiar plants and animals from their homelands, in addition to those they introduced for food, clothing, commercial or sport reasons. Some of these introduced animals became pests, and this led to ill-informed introductions of predators in the hope that they would control these pests. A well-known example was the introduction of mustelids, cited previously, to control rabbits despite vigorous scientific advice both in New Zealand and overseas. This led to the subsequent near extinction of some flightless birds on the mainland (Hill and Hill 1987). Third, 'the inevitable displacement of weak southern hemisphere species by more vigorous northern hemisphere species that had evolved with greater competition was perceived as a universal law by most scientists and laymen alike' during the nineteenth and early twentieth centuries (Starr and Lochhead 2002, p. 121). Until at least the 1880s it was generally considered futile to try to protect indigenous fauna and flora. This displacement theory was finally disproved in New Zealand by the botanist Leonard Cockayne in the 1920s.

The New Zealand public generally dislike insects and most are only interested in how to kill them. They focus on insects as pests and generally have little recognition of the importance of the vast majority of beneficial insects. While this attitude is slowly changing and people are increasingly enquiring about unusual insects or insects they have not seen before, we are still a long way from educating the majority of people in the important and essential roles that insects and other invertebrates play in ecosystems. Few people understand or take a national pride in how special and unique our insect fauna is and so it is perhaps surprising that one of the largest and most fearsome looking of New Zealand's insects – weta (see Box 10.4) – have become iconic.

Box 10.4 Weta: 'Flagship Species' for New Zealand Insect Conservation

Two families of wingless orthopterans, called weta, form a distinctive iconic component of the New Zealand insect fauna (Gibbs 2001). The Anostostomatidae comprises five New Zealand genera: *Deinacrida* (giant weta); *Hemideina* (tree weta); *Hemiandrus* (ground weta) and two tusked weta genera, *Anisoura* and *Motuweta*. The Rhaphidophoridae or cave weta are both more species-rich and less well studied. Many of the larger bodied weta are now rare or threatened following the introduction of predatory mammals to New Zealand. This is particularly true of giant weta, which are now considered 'flagships' for New Zealand insect conservation (Watts et al. 2008). Such a trend towards gigantism is often associated with isolated island faunas that have evolved in the absence of mammalian predators and competitors (Daugherty et al. 1993). As a result, several of the 11 species of *Deinacrida* are of high conservation value (Gibbs 1998, 1999). Weta have been viewed in an ecosystem role as 'invertebrate mice' in the ecosystem – they are often of similar size, forage at night, have omnivorous habits, use diurnal retreats, are polygamous, and even their droppings are so similar to those of rodents that they can easily be confused with them (Ramsay 1978b).

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Box 10.4 (continued)

Fig. 10.4 Wellington tree weta harem inside a 'weta motel' artificial refuge, Matiu/Somes Island, Wellington Harbour (Photo: George Gibbs)

All New Zealanders recognise weta and they have become iconic through continued publicity despite their often fearsome appearance. Weta are now so well known that the name is starting to be used as a brand name (e.g. Weta Marine and the New Zealand rock band Weta) but perhaps it is best known for the visual effects company, Weta Digital Ltd, and the creative design company, Weta Workshops Ltd, both located in Wellington. The popularity of the insects really had its genesis in Wellington through the efforts of researchers at Victoria University of Wellington and Wellington Zoo. It was achieved through publicity in local newspapers, radio and television and by giving the public the opportunity to see and handle weta at meetings and local events. The tree weta species lend themselves to public appearances thanks to their propensity to aggregate in artificial 'weta motel' refuges (Fig. 10.4). These wooden units (see photo) mimic the natural tree galleries and have made it possible for everybody from school groups to research workers to have easy access to wild populations. Giant weta have also been able to win over the public through the particularly docile Cook Strait giant weta, *Deinacrida rugosa,* which was readily available. Since then the Mahoenui giant weta, *Deinacrida mahoenui*, which is almost as docile, has similarly been popularised in the Waikato region of New Zealand (Fig. 10.5).

Not only have weta also been used extensively for research perhaps partly because of their relatively large size and interesting behaviour (e.g. Field 2001),

Box 10.4 (continued)

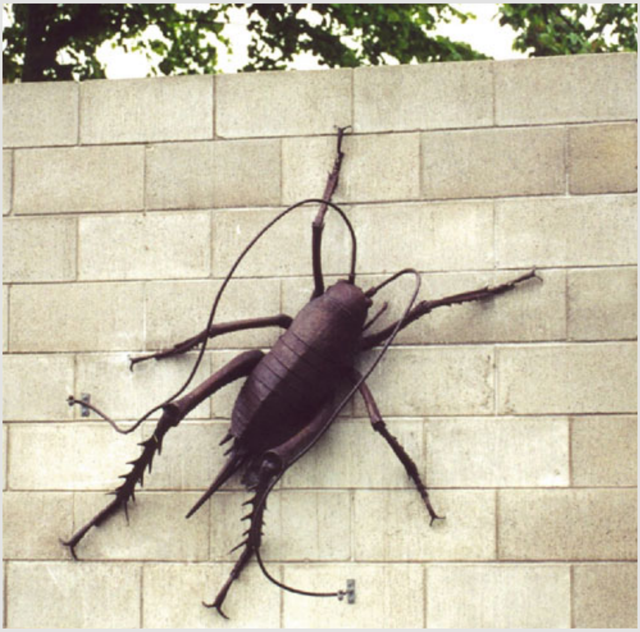

Fig. 10.5 Bronze sculpture of a female Mahoenui giant weta in Te Kuiti's main street (Photo: Danny Thornburrow)

they have long been a focus for conservation management techniques such as translocation. Translocating native species in New Zealand, particularly birds, has become an important aspect of conservation management and there has been a clear taxonomic bias in favour of bird transfer projects although this is slowly changing as increasing numbers of invertebrates are relocated. Between 2000 and 2008, for example, there were 26 translocations of insects in New Zealand whereas prior to this only 13 translocations of insects had ever been done (Sherley et al. 2010). Of these, weta were translocated most frequently (26), and many of these transfers were to islands or sanctuaries on the mainland that were free of introduced mammals (Watts et al. 2008; Sherley et al. 2010). The early transfers of weta were aimed at conserving a species by establishing multiple populations. For example, 2050 Mahoenui giant weta have been transferred to seven new locations in 32 different releases since 1989 (Watts and Thornburrow 2009). Over the past four decades, methods for both transferring weta and monitoring them have become more sophisticated (Watts et al. 2008). More recently, weta transfers have been included in restoration programmes for some islands and mammal-free sanctuaries on the New Zealand mainland. These transfers involve the preparation of comprehensive proposals that are subjected to formal review and approval processes. In addition, they can indicate important research opportunities.

10.4 Insect Conservation

The value of long-term studies for understanding the distinction between invertebrate and vertebrate conservation was highlighted in an outstanding contribution on Coleoptera by Kuschel (1990). While employed at the Systematics Section of DSIR, Auckland, Kuschel, who lived in Lynfield, collected every beetle species he could find over 15 years in a small degraded reserve adjacent to his residential area. The resultant list of 982 beetle species, 753 of them endemic, confirms that urban remnants of indigenous vegetation, even after infiltration by a suite of introduced mammalian predators, can be a vital refuge for native invertebrates. One hundred and thirty species were new to science. On the basis of these beetle species, Kuschel calculated that the surveyed area could contain as many as 3,400 different indigenous species of insects. In contrast, this urban patch of remnant forest held only nine native vertebrates – one skink and seven widespread resident birds plus one migratory species. In total, this Auckland reserve supported approximately 8% of indigenous vascular plant species and about the same percentage of the native beetle fauna. The implication is that, while we need National Park-sized pristine areas to maintain much of our endemic invertebrate fauna, even very small remnant patches can play a valuable role.

At this point it is necessary to make a general observation about the type of New Zealand situations that require conservation management and draw a comparison between the many successful vertebrate programmes in New Zealand (mainly with bird species) and the lack of such examples with invertebrates. The near absence of terrestrial mammals in New Zealand's evolutionary history (apart from bats) has 'simplified' the approach to many conservation projects (where vertebrates or large invertebrates are involved) because the cause of decline can often be attributed to an introduced predator or suite of predators. Eradicating the predator, or establishing the target species on a predator-free island, can often solve the problem. With smaller invertebrates, the causal agent(s) can be much more difficult to determine and hence to ameliorate. Sometimes the causal agent was obvious, (e.g. with the large iconic weta species) and sometimes it was not. Thus, large *Deinacrida* giant weta species became extinct on the main islands before 1900, due to the invasion of rats, and this paralleled the better known bird examples. Also, like the birds, these weta survived in places such as some islands and the alpine regions of the South Island that Norway rats (*Rattus norvegicus*) or Ship rats (*R. rattus*) did not colonise. In contrast, the Forest Ringlet butterfly is one of many examples where the cause of decline is not as apparent.

10.5 Direct Protection of Insects: Legal Protection

Diverse legislation now protects indigenous insects either explicitly as in the Wildlife Act 1953 or by proxy whereby insects are indirectly protected such as by the legal protection of land and the legislation affecting border security.

Box 10.5 Forest Ringlet Butterfly, *Dodonidia helmsii*

Many an entomologist who has spent his or her working life fossicking for insects around New Zealand has never set eyes on this elusive forest butterfly (Fig. 10.6). The chance of doing so is receding still further as reports of its demise come to hand. Discovered by Richard Helms near Greymouth in 1881, the year G.V. Hudson arrived in New Zealand, this secretive forest butterfly has never been regarded as common. Although no comprehensive survey has been conducted, several locations close to urban settlements around Auckland and Hutt Valley appear to have lost their populations since the 1980s.

This, the largest New Zealand satyrine, is its only forest-dwelling butterfly. It depends on the presence of the larger forest grasses (*Chionochloa* spp.) or sedges (*Gahnia* spp.) for its larval foodplant. The adult flies during a restricted period, but this may vary widely from place to place and even at one locality. Overall records show flight activity any time between October and March, depending on local factors and whether the locality supports a 1-year or 2-year brood pattern. The butterfly overwinters as young larvae, which resume feeding in September–October.

Although larvae are frequently heavily parasitised by an endemic tachinid fly larva, and are also attacked by other insect parasitoids (of both eggs and pupae), there is no evidence that these have been responsible for the current decline. However, it is suspected that the agent of decline is most likely to be another insect, possibly one introduced for biocontrol purposes. The agents that have received most attention are the predaceous European vespid wasps, *Vespula germanica* and *V. vulgaris*. This is pure speculation, based on the loss of viability in butterfly populations at lowland sites near built-up areas where the wasps thrive and the fact that higher altitude locations (e.g. Lewis Pass and the Tongariro National Park) appear unaffected. The potential crisis this endemic species is facing is indicative of the intractable nature of some invertebrate conservation issues where determining the agent of decline can be so enigmatic (Fig. 10.6).

Fig. 10.6 Forest Ringlet butterfly, *Dodonidia helmsii*, a species which is critically threatened in some regions, especially close to urban areas, yet thriving in others (Photo: Owen Spearpoint, East Harbour Regional Park; Illustration by G.V. Hudson (1928))

10.5.1 Legal Protection of Insects

Explicit legal protection of some of the rarer insects, together with several other invertebrates, first occurred when the Wildlife Act 1953 was amended in 1980. The species included in the Amendment originated from a list of 23 rare and threatened insects that Ramsay and Gardner (1977) provided for the purpose of discussion and debate. This list was subsequently modified by the addition of three more insect species (Newman 1980) and 23 of the species were incorporated into the 1980 Amendment to the Act. The listed species were added without sufficient consultation with entomologists because time was limited when the opportunity arose to amend the Act (Watt 1981) but the same insects remained absolutely protected until 2010 when the list was changed by Order in Council following extensive consultation. Now 15 insect species are listed together with two genera (*Deinacrida* – giant weta – with 11 species and *Geodorcus* – stag beetles – with 10 species) (Wildlife Act 1953). Some giant weta and stag beetles in these genera are not threatened but protecting complete genera avoids the difficulty that staff at the borders would otherwise have in distinguishing protected species from closely-related common species.

No New Zealand insects are listed under the New Zealand CITES (Convention on International Trade in Endangered Species) legislation because there is no evidence that any protected indigenous insects have been traded. Non-threatened indigenous New Zealand insects are, however, frequently exported and traded overseas.

10.5.2 Legal Protection of Habitat

The most important legislation relating to insect conservation in New Zealand is legal protection of land because this safeguards habitat. However, such legal protection had very slow beginnings as mentioned above. Relatively little land was legally protected during the nineteenth century and seldom was any reserved for the purpose of protecting fauna. Most reserves were made either to ensure a continued supply of wood or to protect scenery for revenue earned through tourism, although reserves were later also formed for soil and water conservation (Nightingale and Dingle 2003; Starr and Lochhead 2002). The first land to be specifically protected for fauna, by an act of parliament in 1891, was Resolution Island, Fiordland followed soon after by Secretary Island (1893), Little Barrier Island (1894–1897), and Kapiti Island (1897). All were legally protected to protect indigenous birds (Starr and Lochhead 2002). During the twentieth century the pace of land protection increased largely through political pressure from a wide variety of voluntary nature conservation organisations (Lochhead 1994; Nightingale and Dingle 2003) with the result that New Zealand now has a wide variety of local-body and national reserves, with the largest portion, about 30% of New Zealand, administered by DOC as conservation estate. The majority of such land is located in the high country and yet even here only a portion of the biodiversity is protected, and those environments where the risk of biodiversity loss is greatest still remain poorly represented today (Walker et al. 2004).

10.5.3 Land Protected Specifically for Insects

The coleopterist Charles Watt, a taxonomist with DSIR Entomology Division, can be credited with the first initiative to establish special insect reserves. In 1974 he recommended reserving an area at Capleston on the West Coast, significant for its role as the type locality for 61 species of beetles described by Thomas Broun (Watt 1974). The area was shown as a biological reserve on NZ Forest Service maps, but it was never formally gazetted. Dr Watt's efforts to secure a reserve on a block of sparse sandy native grassland at Cromwell for the flightless Cromwell Chafer Beetle, *Prodontria lewisi*, marks the start of official insect conservation in New Zealand (Watt 1975, 1979). This beetle, which only occurred in the vicinity of Cromwell, had been described by Broun in 1904 and spasmodically collected from 1944 until 1968. A proposal to consider hydroelectric development in the area stimulated Dr Watt to organise surveys of the area in 1974 and 1975, during which time he identified the most suitable block of land for the reserve. This was surveyed for its flora and insects, fenced by the Cromwell Borough Council in 1979, and purchased by the Department of Lands and Survey for a reserve in 1982. So far as is known, the beetle still survives only within this designated area (81 ha). Management has involved rabbit control, some planting of silver tussock, and subsequent insect surveys (Barratt 2007). Interestingly, in 1991 funding for research on this endangered chafer was obtained from Enterprise Cars, Lower Hutt, an importer of used vehicles, who advertised a donation of $20 for each car sold over the month of June. The Volkswagen beetle was used as an icon for this project.

The next area reserved for insects was on a steep hillside on the south coast of Wellington. This was originally set aside in 1983 to protect the threatened Speargrass Weevil, *Lyperobius huttoni.* The original 4.65 ha area was fenced to exclude domestic farm animals from damaging the weevil's foodplant, a speargrass (*Aciphylla squarrosa*), but the plants became overgrown by other vegetation and died out. The area was enlarged to 57.8 ha of coastal cliffs and covenanted in 2010 to protect both speargrass and other uncommon plant species (L. Adams, personal communication).

The third area reserved for insects, the Mahoenui Giant Weta Scientific Reserve (182 ha), was purchased by DOC in 1990. It contains a mosaic of introduced gorse (*Ulex europaeus*), native shrubs and introduced grasses. Gorse, a seral weed elsewhere in New Zealand, provides food and shelter for the weta (*Deinacrida mahoenui*, Anostostomatidae) as well as protection from rats. Sherley (1992) and Sherley and Hayes (1993) recommended maintaining the vegetation mosaic by periodically allowing domestic cattle into the reserve to break paths through the gorse and encouraging feral goats, also considered pests elsewhere, because their browsing on gorse forms a dense hedge-like protective foliage in which the weta roost.

Finally, Pollen Island in the Waitemata Harbour was leased by the Royal Forest and Bird Protection Society in 1995 partly to protect the habitat of a rare moth (*Bactra* sp., Tortricidae). This island later became part of the Motu Manawa Marine Reserve in 2005. The moth was originally thought to be restricted to Pollen Island in the reserve (Green 1986; Bellingham 1989) and, although it has since been found elsewhere and may even be a non-endemic species, management of the reserve is still significantly influenced by concern for this moth.

10.5.4 Other Indirect Legislative Protection

New Zealand has strict procedures, supported by appropriate legislation, to prevent the introduction of alien organisms entering the country. Again, these procedures serve as indirect protection for our indigenous insect fauna by preventing the introduction of new predators, parasites, competitors and organisms that may adversely affect them, their food sources or their habitats. While the original aim of these procedures, which are constantly being reviewed and improved, was to prevent pests and medically or agriculturally important species gaining entry and damaging the economy, protection of native biodiversity is now also seen as important. New organisms can still be introduced, such as those used for biological control, but this now involves extensive scrutiny by the Environmental Risk Management Authority (ERMA) to ensure they do not adversely affect non-target species. The process involves 'concentric' screening whereby their impacts are tested on all species they are likely to affect and their close relatives, but progressively fewer species are tested the less closely related they are. No process is perfect, however, and examples of past border security failures include the accidental establishments of the Varroa Bee Mite (*Varroa destructor*) as well as a saltmarsh mosquito (*Ochlerotatus camptorhyncus*) and the Painted Apple moth (*Teia anartoides)*. The latter two were both subsequently eradicated using aerial blanket spraying (Biosecurity New Zealand 2010; Suckling et al. 2007).

10.6 An Acceptable Endeavour

Following the New Zealand Entomological Society Conservation Seminar of 1986 and the formation of DOC in 1987 insect conservation became recognised as a valid pursuit in its own right. Scientific publications specifically on conservation of New Zealand insects only started to appear in increasing numbers after 1987 even though the first had appeared in 1975 (Watt 1975) (Fig. 10.7). Since the formation of DOC there has also been a huge increase in documented information in the form of unpublished reports on all aspects of insect conservation from surveys and monitoring to accounts of direct management procedures such as translocations and the results of unpublished research.

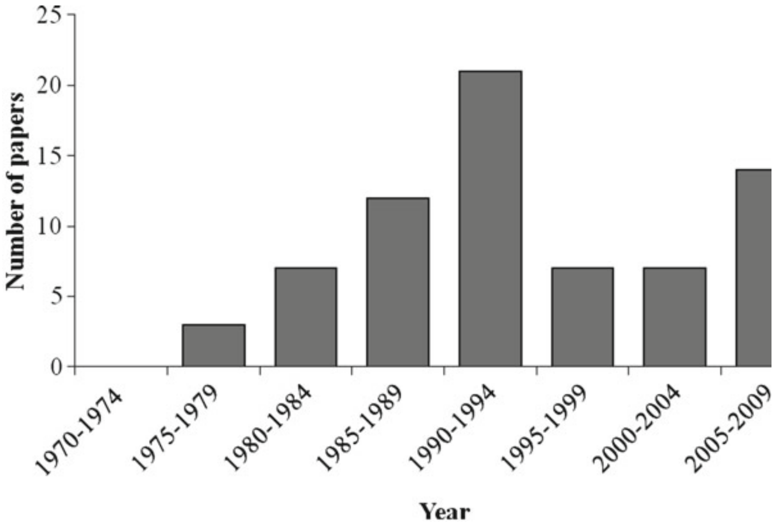

Fig. 10.7 Number of articles on the conservation of New Zealand insects published in selected journals during 5-year periods (Data from Journal of the Royal Society of New Zealand, Journal of Insect Conservation, New Zealand Entomologist, New Zealand Journal of Zoology, Pacific Conservation Biology and The Weta)

10.6.1 The Department of Conservation

The formation of DOC in April 1987 (Conservation Act 1987) brought together almost all the major conservation functions that were previously spread amongst various government agencies. With respect to insects, the importance of this administrative change was that insects and indeed all invertebrates, particularly those that were threatened, came to be included under the same administrative systems and procedures as other threatened species in DOC's business. For the first time, insects could compete with native vertebrates and plants for funding and resources to undertake essential scientific investigation and for conservation management. There was an initial lag because the original fauna people in DOC came from the Wildlife Service and the Department of Lands and Survey (Anon. 1995), which had a traditional focus on native birds and plants, and to a lesser extent on tuatara, lizards and frogs. These people became the fauna officers in DOC, based in the Conservancies and Field Centres (DOC was a strongly decentralised organisation) as well as the scientists, based in Head Office, who supported them with advice and applied investigations (DOC's senior management has consistently maintained a policy of basing its conservation management on best available science). Research on endangered insects had previously been undertaken by the Ecology Division, DSIR, led by Mike Meads and by entomologists in the Entomology Division of DSIR. Unfortunately, when DSIR was disestablished in 1992 none of the entomologists there moved to DOC. Instead, early in 1988, an existing position within DOC held by Greg Sherley became converted to invertebrate research and Dr Sherley was subsequently responsible for instigating many of the initiatives relating to insect conservation. He encouraged discussion on research needs relating to the conservation of insects and other invertebrates in a series of talks (Ramsay et al. 1988; Sherley 1989a, b, 1994a, 1997, 1999) and held a workshop specifically to advance insect conservation in New Zealand (Cresswell and Veitch 1994). He also successfully bid for sufficient funds to create an invertebrate specialist position in each Conservancy. This signalled the importance of invertebrates, an outlook initially adopted by all the Conservancies even though some subsequently directed the funds elsewhere. The realisation and acceptance within DOC of the importance of insect conservation was aided by other individuals within DOC, and particularly the Waikato Conservancy by supporting high profile research on Mahoenui Weta (*Deinacrida mahoenui*, Orthoptera: Anostostomatidae) and Mercury Islands Tusked Weta (*Motuweta isolata*, Anostostomatide) (McIntyre 1998; Sherley and Hayes 1993). Sherley's position in head office at DOC allowed him to constantly improve the profile of invertebrates within the organisation so that, for example, 33 insects together with 52 other invertebrates were included under four threat levels when the first catalogue of threatened species was produced (Molloy and Davis 1992). This resulted from extensive interviews between Sherley and entomologists throughout New Zealand. Since then the number of insects listed as threatened has steadily increased in subsequent publications (Molloy et al. 1994; Hitchmough 2002), with the latest listing 144 threatened insect taxa together with another 68 identified as having populations that are gradually declining, 189 that are naturally rare and 127 that are data deficient (Hitchmough et al. 2007). Threatened insect taxa are now given serious consideration under the Resource Management Act 1991when consents are sought for developing land. In addition, these lists, together with the publications on research priorities for insect conservation, have helped encourage student research on projects relating to endangered insects (e.g. Richards 1994; Domett 1996; Hunt 1996; Stronge et al. 1997; Brignall-Thayer 1998; Anderson 2000; Guignion 2005; Seldon 2006). DOC also provided financial support for research on rare insects to over 16 students (e.g. Jowett 1991; Townsend 1994).

Insect conservation has benefitted by the requirement to produce 'threatened species recovery plans' and documents that are generally referred to as 'action plans'. Both are described in detail by McGuinness (2007). Three multispecies recovery plans were produced for insects: those for weta (Sherley 1998) and carabid beetles (McGuinness 2003) were published; the third plan on short-horned grasshoppers (Walker 2003) was not published; all were externally refereed. These recovery plans detailed the necessary management procedures and guided DOC in allocating resources to undertake the work. The management objectives were also implemented in the DOC's business plans. The recovery plans also promoted wider interest and discussion among the general public, thereby motivating support for invertebrate conservation in general; they also provided leverage for funding bids. For example, private sector groups building wildlife sanctuaries used the recovery

Box 10.6 Gregory Howard Sherley (1956–)

Greg Sherley (Fig. 10.8) was brought up in small New Zealand country towns where ready access to the outdoors fostered his abiding interest in wildlife and predisposed him to do his first degree in zoology. A professional career as a wildlife officer in the New Zealand Wildlife Service followed where he surveyed fauna, including invertebrates. During this period he took leave to complete an Honours degree followed by a Ph.D. in ornithology. Both included extensive work with invertebrates as food for birds. An undergraduate and later a post-graduate paper in invertebrate ecology helped his 'conversion' to invertebrate conservation after he joined the New Zealand Department of Conservation (DOC) as a scientist in 1987.

While working for DOC, Greg was for some years the sole advocate for invertebrate conservation in Head Office. He worked with like-minded colleagues both there and in the conservancies to establish specialist invertebrate technical officer positions. At the same time he carried out basic surveys and ecological research, mainly on threatened invertebrates, especially insects and land snails. This research aimed to reveal the status of and threats to them and their habitats and also ways to mitigate these threats, which included the use of toxins for pest mammal control. He was very active in advocacy, both with the public (e.g. news media, documentaries) and within the DOC. The latter resulted in the appointment of additional invertebrate conservation scientists and in the permanent establishment of invertebrate conservation as part of the general business of the DOC; for example, threatened species management plans and protection work, research funding and advocacy work all subsequently included invertebrates. Before leaving DOC, Greg spent 3 years with the South Pacific Regional Environmental Programme. He now works for the United Nations Development Programme in the Pacific area.

Fig. 10.8 Greg Sherley examining a Mercury Island tusked weta (Photo: Ian Stringer)

plans to leverage their funding and help justify their wildlife management work. The three insect recovery plans, which had 5-year periods, have now expired but most of their objectives were achieved. Producing recovery plans involves a considerable investment of time and effort so DOC is investigating alternative ways of optimising its management of threatened species to ensure the most efficient use of the available resources. The first objective is to conserve 'nationally threatened species to ensure their persistence' (Department of Conservation 2010, p. 20). The aim is to secure from extinction and promote the long-term recovery of as many species as possible. In relation to this, DOC has recently investigated this using an optimisation process involving assessing the risk of extinction for every threatened species and specifying what management procedures are necessary together with the associated costs to prevent extinction. However, information for most insects is lacking so the best guesses by specialist entomologists were collected and are currently being used to decide priorities. The second objective is to improve 'populations of nationally iconic species' (Department of Conservation 2010, p. 20). The intention is to support populations of some iconic species, including some insects, to a level over and above what is required to ensure their persistence. More detailed information about the underlying reasons for optimisation and the processes employed is provided by O'Connor et al. (2010).

Recovery plans are associated with 'recovery groups', which comprise the relevant conservation managers, scientists and other experts that work with the species concerned. Their role is to provide expert advice and further guide and oversee the management of the species whenever necessary. In the case of the Mercury Islands Tusked Weta, which survived in low numbers on a small dry island, a formal recovery plan was not used once it was realised that the management of this species required a rapidly responsive, highly flexible and careful approach. Instead, an individual recovery group was formed of expert field staff, managers and scientists who took over responsibility for the species' recovery. This recovery group met annually from 1998 to develop strategies (the minutes effectively became the recovery plan) with frequent communication between members for making day-to-decisions (Gibbs 2006). The outcome was that these weta are now well established on two larger mammal-free islands and have also been released on three more mammal-free islands in 2008 but it is too soon to know how successful these latter three releases have been (Stringer and Chappell 2008; Watts et al. 2008).

Comprehensive invertebrate action plans published by DOC in 2001 included information on the known distribution, threats, future management needs and research, survey or monitoring needs for all of the 162 insect species listed as threatened or data deficient at the time (McGuinness 2001). It brought together under one easily accessed publication all previously published information relating to conservation from a wealth of smaller publications on individual insects or insect groups such as *Geodorcus* stag beetles, weta and many moths (e.g. Sherley 1994b, c, 1999; Sherley et al. 1994; Patrick and Dugdale 2000), as well as information obtained directly from taxonomists and their publications.

Recently, DOC has also been developing invertebrate conservation strategies for individual conservancies. These strategies generally list threatened insects within the conservancy together with relevant information on them. They aim to foster new research and the collection of additional information on these threatened taxa. They provide guidance for implementing recovery planning, and identify key sites where invertebrate conservation should be a priority. The first strategy, which was produced for Southland, also aimed to improve public awareness of threatened invertebrates in general (Edwards 2001). The second, produced for the Canterbury Conservancy, is supported by separate work plans for each of the five Area Offices; the work plans provide detailed actions required for each threatened species (Evans and Chinn 2010). Two more conservation strategies are at advanced stages of development – for the Wellington/Hawke's Bay Conservancy (L. Adams and J. Griffith, DOC, personal communication) and the Nelson Marlborough Conservancy (I. Millar, DOC, personal communication). The Wellington/Hawke's Bay strategy will also seek to incorporate insect monitoring into large-scale management activities to identify how the management actions affect insects. This is being supported by the development of a 'toolbox' of standard methods for monitoring insects for use by DOC field staff. All conservation work on insects carried out by DOC is also supported by a network of invertebrate specialists who meet semi-annually.

Finally, DOC publicises insect conservation with newspaper articles, television news stories and documentaries. It also holds information resources to support invertebrate conservation in the form of publications, photographs and information articles all of which are freely available to the general public.

10.7 Insect Conservation on Islands – In the Footsteps of the Ornithologists

Islands have played a significant role in New Zealand conservation because they contain a disproportionately large amount of our biological wealth (Daugherty et al. 1990). Relict populations of endemic insects survive on islands that have remained mammal-free (at least 88 of the 330 islands >5 ha; Atkinson and Taylor 1992). As such insects tend to be large, slow, flightless and therefore vulnerable to predation from introduced mammals, they rapidly disappeared from the mainland after mammals invaded New Zealand. For example, the Cook Strait Giant Weta, a medium-sized ground-dwelling species, became extinct on the lower North Island over 100 years ago it but it did survive on rat-free islands in Cook Strait – Stephens, Mana, and Trio Islands and was last seen on Kapiti Island in 1913 (Gibbs 2001).

Advances in the ability to eliminate introduced mammals from islands have resulted in their successful eradication from more than 90 islands ranging in size from 1 ha (Maria Island) to 11,300 ha (Campbell Island) (Towns and Broome 2003). The elimination of rodents, in particular, has hugely benefited insects although the removal of other mammals has also helped through changing predation regimes and improving habitat (Clout and Russell 2006). Such mammal-free islands present ideal opportunities to conserve threatened insect species by establishing additional populations provided the species were likely to have once been present. This is similar to using islands as refuges to protect native birds and reptiles which has been extensively employed in New Zealand. As increasing attention is focused on their conservation we are beginning to transfer increasing numbers of insect species, or consider them for transfer (Sherley et al. 2010). Examples include the first translocation of an insect in New Zealand – Cook Strait Giant Weta from Mana Island to Maud Island – and other weta which were carried out to reduce the chances of accidental extinction as well as to contribute to the restoration of the fauna of other islands (Watts et al. 2008). The effort that has gone into translocating these and other insects shows an encouraging and increasing focus on conserving insects, although sometimes insects are considered for transfer not for their own conservation but to act as a food source for rare vertebrate species. The transfer of Auckland Tree Weta (*Hemideina thoracica*) to East Island in 2002 is an example of this – it was undertaken to provide a food source for Tuatara (*Sphenodon punctatus*) in preparation for their future release (Watts et al. 2008). The transfer of weta to islands in New Zealand is certainly leading the development of reintroduction biology for insects by exploring and exploiting a variety of transfer and monitoring methods that may have applications to other conservation initiatives involving insects in the future (Watts et al. 2008).

10.8 Mainland Sanctuaries – Public/Private Partnerships

Interest in the creation of conservation areas by interest groups has followed advances in mammal control and the advent of predator-proof fences. These allow mammals to be controlled to low levels or completely eradicated from parts of the New Zealand mainland. The result has been a rapid increase in such projects and there are now 35 in the North Island alone (J. Innes, Landcare Research 2010, personal communication). The largest of these involves 47 km of predator-proof fence enclosing Maungatautari, an area of 3,363 ha. Residents at Cape Kidnappers have adopted a slightly different approach by excluding most mammals from the area with an excluding fence (9.5 km) and controlling those mammals that remain to low densities. In this case the area (2,200 ha) is a mosaic of native vegetation, dwellings and productive land (Anon. 2010). All such groups want to introduce native birds and iconic reptiles as soon as possible, sometimes for their own interest, sometimes to attract visitors and thereby provide funding opportunities, or sometimes for both reasons. Underlying this, though, is also growing interest in having examples of iconic insects, which should be encouraged because these conservation areas often provide easy access for the general public and have huge potential for increasing the public's general awareness of insect conservation. The recent introduction of the Cook Strait Giant Weta to Zealandia (previously known as Karori Wildlife Sanctuary) in Wellington is a good example. This was the first reintroduction of a giant weta back onto the mainland and generated much publicity (Watts et al. 2008). Another example is Warrenheip near Lake Karapiro where Mahoenui Giant Weta were released between 2001 and 2002. These normally secretive insects are now so abundant there that they can commonly be seen resting out in the open on tree trunks and vegetation. Now the Maungatautari Ecological Island Trust is also planning to acquire Mahoenui Giant Weta for its predator-free mainland sanctuary.

10.9 The Future

As DOC is responsible for the conservation of threatened insects as well as for the rest of the biota on the conservation estate (about 30% of the land area of New Zealand) so permits are required to work on insects on such public land and this, together with DOC's direct involvement with threatened insects, has led to the perception that all insect conservation resides within DOC. This not correct: there are many opportunities for individuals or organisations to play significant roles. For example, the Monarch Butterfly Trust is broadening their interest to include endemic butterflies and is showing potential to contribute to insect conservation. The opportunity also exists for the Entomological Society of New Zealand, which took an early lead in insect conservation, to take a leading role again. The society represents virtually everyone who is likely to know about the status of particular insect species – their location, rareness and the identity of threatened species – and its members are constantly active in the field. We suggest the society should accept responsibility to tell government about conservation issues as it becomes aware of them. The Society could certainly play a significant role by pushing for reservations, management actions and public awareness in our non-conservation estate areas such as road reserves, local parks and privately owned land.

The need for more specialised tools to help make insect conservation more effective and efficient is also recognised. One example is predictive modelling of insect distributions, as has been done for land snails (Overton et al. 2009). The problem with New Zealand insects is their huge diversity (only about one quarter of our presumed species have been named so far) and the rapid geographic change in species distributions, especially of flightless ones. Predictive distributions overcome the difficulty that even expert entomologists let alone DOC field workers can have identifying many species in the field. Such predictive models are useful, for example, for including an insect perspective when designing reserves or for modifying areas where mammalian predator control is undertaken for other purposes where they can be used to maximize the number of additional species that also benefit. Other examples include predicting where unwanted introduced insect predators are likely to threaten the native fauna, as was done for Argentine ants (*Linepithema humile*), or using geographic information systems for predicting where species occur, as was done for a rare ground weta (Muckle and Chinn 2010).

Overall, however, we believe that the greatest need relating to insect conservation is in educating the general public to appreciate how different and special our fauna is. Over 90% of most groups of New Zealand insects are endemic, and they include forms that are just as different, ancient and unusual globally as are our native birds. If New Zealanders could be persuaded to take greater national pride in the outstanding value of our endemic insect fauna, as they already do for their native forests, birds and tuatara, our arthropods could be assured of a secure future. There is certainly a lot of readily available information about New Zealand insects including websites (e.g. Landcare Research's – What bug is that?), programmes run by museums for children and many books including easily followed basic identification guides (e.g. Crowe 2002; Early 2009). However, most of this is accessed by people who are already interested in insects and relatively little has been done to champion wider public awareness of insects, with the exception of Ruud Kleinpaste, the 'bug man', who has been doing this now for several decades by public talks, printed articles and through television. It is, however, encouraging that steps are being taken towards promoting insect conservation in schools. A recent government-funded web-based science education initiative, the Science Learning Hub, includes 'New Zealand science stories'. This has information and resources for teachers wanting to explore insect conservation with their students. One of the case studies concerns the exciting discovery of a new genus and species of endemic moth, *Houdinia flexilissima* (Batrachedridae). The very thin caterpillar, nicknamed 'Fred the Thread', lives in the stems of a wetland plant threatened by peat mining. The discovery of this species, the process of describing it, and the conservation management actions that are required to prevent it from going extinct are all explained. The Hub also profiles all the New Zealand butterfly species.

DOC focuses increasingly on protecting and managing ecosystems and the intention is to extend this protection to include a full range of representative ecosystems. This, indirectly, should provide enormous benefits to the insects living within them. DOC will still continue to manage some of the most endangered insect species, and to also draw on the expertise and advice of New Zealand entomologists in order to rank the threat status and risk of extinction of insects. Related work on species optimisation referred to above, is exploring new ways of addressing the need for increasing the numbers of threatened insects that can be managed with the available funding. However, with a total of over 2,700 species at risk (Hitchmough et al. 2007) perhaps the future for many of the 212 insect species that are threatened or with declining populations lies more in the hands of the devoted public.

10.10 Conclusions

We have followed the history of insect conservation in New Zealand from the first expressions of concern by early entomologists through increasing recognition for the need to conserve insects in the 1970s and 1980s to the situation today where insect conservation is fully integrated with the conservation of other fauna and flora. We have also described past and present threats to insects in New Zealand and what mechanisms have been put in place to protect them either directly or indirectly. Few of the very many people involved have been mentioned but we emphasise that insect conservation developed in New Zealand through a collegial process involving discussion of ideas and actions by numerous people including entomologists – both professional and amateur – as well as other people involved or concerned with different aspects of conservation. We have referred to publications of some of the people involved but there are many more that we have had to omit, such as the numerous students who have worked on rare or endangered species or people in local and national government and at all levels within DOC who were receptive to the idea of conserving insects and provided their support.

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Chapter 11
Development and Future of Insect Conservation in South Africa

Michael J. Samways, Michelle Hamer, and Ruan Veldtman

11.1 The South African Insect Fauna

When considering the history of insect conservation activities in South Africa, it is important to consider its biodiversity value in a global context. The country has been rated as the third most biologically diverse in the world after Indonesia and Brazil. It also has within its borders three of the world's 34 biodiversity hotspots (Mittermeier et al. 2004). In discussions of South Africa's biodiversity, it is mostly the country's flora that is recognised as being of enormous conservation value, followed by the variety of large mammals and rich bird fauna that form the basis of a large ecotourism industry. The contribution of the insect fauna to the country's biodiversity, in terms of both richness and functioning, is less well known among the public, decision makers and even some conservation scientists. Insect conservation can be considered a relatively new and possibly also a neglected discipline in South Africa, but there has certainly been some progress through various activities, at both landscape and species levels. The future of insect conservation in South Africa faces both challenges and opportunities, most of which are shared with other parts of the world with high and irreplaceable biodiversity.

M.J. Samways (✉)
Department of Conservation Biology and Entomology, University of Stellenbosch,
Private Bag XI, Matieland 7602, South Africa
e-mail: Samways@sun.ac.za

M. Hamer
Biosystematics Division, South African National Biodiversity Institute,
Private Bag X101, Pretoria, Gauteng 0001, South Africa

R. Veldtman
Applied Biodiversity Research, South African National Biodiversity Institute,
Kirstenbosch Research Centre,Private Bag X7, Claremont 7735, South Africa

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11.2 South Africa's Biomes

As insect diversity is so intimately associated with that of plants, it is important to recognize the floristic value of the country. Nine biomes are represented in South Africa, and their uniqueness and variety contribute to the country having exceptionally rich biodiversity (Mucina and Rutherford 2006). The winter-rainfall Fynbos Biome in the south-west, and the drier Succulent Karoo Biomes form the smallest of the world's six floristic kingdoms, and the Succulent Karoo Biome has the highest diversity of succulent plants in the world, and is the richest semi-desert (Mucina and Rutherford 2006). High elevation, inland Grassland has a large number of endemic plant species, while the Albany Thicket in the south east of South Africa is recognised for its combination of evolutionarily ancient plants intermediate between Savanna, Nama Karoo and Subtropical Forest. The high richness, endemism and general uniqueness of these biomes are focused on their flora which has largely overshadowed their insect fauna, although the species richness of certain plant-feeding insect groups, such as gall-insects, does track that of plants (Wright and Samways 1998, 2000; but see Veldtman and McGeoch 2003).

Biomes are identified largely on the basis of vegetation type, with some consideration of climate. The question of whether insect species richness and levels of endemism match those of the renowned Fynbos and Succulent Karoo plants has received some attention from researchers. While plant host specificity may be expected to result in at least some insect communities being linked to biomes, the mobility of insects, and generalist species could mean that community boundaries are less distinct than areas defined by their vegetation. Our knowledge of the distributions of most insect species is incomplete which means that more experimental approaches have been used to assess insect communities' relationships with biomes. Procheş and Cowling (2007) found that there was some impact of biome on insect community structure, but communities were less distinctive than vegetation structure in plots they sampled but using only sweep netting which would have biased the results. Using the same data, Procheş and Cowling (2006) found that there was a positive relationship between plant and insect species richness in Fynbos, Grassland, Thicket and Nama Karoo biomes. They later used a different approach, examining plant phylogenetic diversity to predict insect diversity patterns (Procheş et al. 2009), and suggested that it is likely that the same abiotic factors responsible for plant radiations at a higher taxonomic level, as well as processes such as migrations and extinctions have lead to similar patterns for insects over broad scales. The Cape Floristic Region, as a hotspot of plant diversity, is also a centre of bee diversity (Kuhlmann 2009), and a similar trend has been found for dragonflies, some beetles, pollen wasps and antlions and lacewings. This provides some consolation in the sense that the attention that plant communities in these biomes receives may also act largely to protect a unique insect fauna (Fig. 11.1).

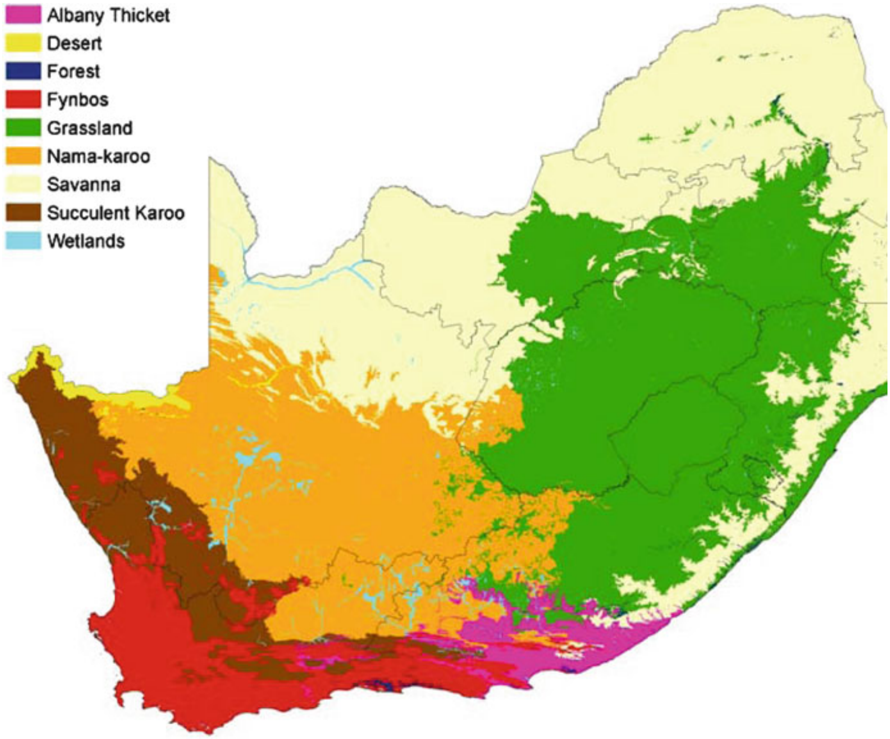

Fig. 11.1 Map showing biomes of South Africa, Lesotho and Swaziland (From the national Spatial Biodiversity Assessment, 2004 (Driver et al. 2005, courtesy of SANBI))

11.3 Taxonomic Representativeness

The understanding that in order to conserve biodiversity, knowledge of which species are present and where they occur is well established. Over the last 250 years, there has been a sustained effort to document the insect fauna of South Africa but just how far we are from achieving the necessary understanding is not known. The last comprehensive assessment of insect diversity in southern Africa was provided by Scholtz and Holm (1985), where the number of species was provided in each family account. The values presented were later summarised by Scholtz and Chown (1995), and since then no new counts by family or even order have been provided, plus no counts have been published for South Africa as an individual country. The total described insect diversity for southern Africa was given by Scholtz and Chown (1995) as 569 families, 7,753 genera and 43,565 species, but these figures are now 25 years old, and considerably more species are being discovered, even in well-known and highly conspicuous groups such as dragonflies (Samways 2008a) and katydids (Naskrecki et al. 2008; Naskrecki and Bazelet 2009), or are yet to be discovered in poorly known groups such as the parasitic Hymenoptera. One of the reasons for many of these new discoveries is that besides searches being made in new areas (bearing in mind South Africa's high beta and gamma diversity), searches are also being made at different times of the year, leading to the discovery of distinct seasonal assemblages (Samways and Grant 2006a). Scholtz and Chown (1995), based on the extent of semi-desert, savanna and forest (considered to be species poor) in South Africa, and the fact that taxonomists were not finding many new species in the region, estimated that the actual number of species was likely to be two to three times the known number of species, but they cautioned that this was probably an overestimate. Scholtz (1999) suggested that the insect fauna is likley to be twice as rich as was known at the time. Other figures for estimates of the total richness of the insect fauna have been given as 250,000 (Samways 1994) (Fig. 11.2).

For some insect taxa no revisions or taxonomic contributions have been published in the last 25, or even 50 years, and the species richness values have not changed, but for other taxa, there has been considerable research and the number of known species have increased. In terms of higher taxa, one new order, the Mantophasmatodea or heelwalkers, was described by Klass et al. (2002) from Namibia, and then recorded by Picker et al. (2002a) from South Africa, with five genera and eight species being described from the Western and Northern Cape Provinces. Several of these species, including the type species, were found in museum collections, having been misidentified as nymphal mantids. Damgaard et al. (2008), based on a molecular and morphological investigation of a large amount of material, suggested that 20 or 21 species may be represented in the new order. The actual phylogenetic position of the heelwalkers has been extensively

Fig. 11.2 Even among large and charismatic groups like the dragonflies new species are still being discovered. This large Gilded Presba *Syncordulia legator* is one of two new species in the genus recently discovered in the Cape Floristic Region (Dijkstra et al. 2007) and which diverged 60 million years ago (Ware et al. 2009) (Photo: Michael Samways)

debated and investigated, with some researchers placing it within a Mantodea clade, while others considered it closest to the Phasmatodea, and others placed it the Grylloblattodea. A literature search of ISI listed journals revealed a single new insect family described since 1985, the Natalimyzidae flies (Barraclough and McAlpine 2006). At least 45 new genera were described during this period, but this is likely to be an undercount since non-ISI journals were not accessed. Regrettably, the number of new species described since 1985 is unknown.

The need for comprehensive species lists and inventories has been recognised for at least 30 years, and while these have been produced and published for individual taxa, and there was an effort to provide checklists through a website developed by Martin Villet as an Entomological Society of Southern Africa initiative a number of years ago, this was not maintained, and a co-ordinated inventory of all insect species still does not exist for South Africa. A regularly updated and maintained, annotated checklist of the insects, which includes information on endemism and threat status would be useful for assisting and promoting conservation efforts, as well as for tracking changes in classification, nomenclature and diversity. It is likely that the South African National Biodiversity Institute will become the most logical suppository and manager for this kind of information.

11.4 Levels of Endemism

Considering the high levels of plant endemism (approximately 80% of species are endemic to southern Africa (Goldblatt 1978)), especially associated with the Fynbos and Succulent Karoo biomes, similar levels of insect endemism might be expected. The Cape Floristic Region has bee species endemism of 27.3% (Kuhlmann 2009). However, the moister eastern part of South Africa was also identified as an endemism hotspot, with 29.1% of bee species endemic. Davis (2002) suggested that dung beetle endemism is highest in the southwest and southeast of South Africa, with many Gondwanaland distributed canthonines in forests and the cooler southwest. Within the Canthonini and the Dichotomiini are flightless taxa, most of which are localised endemics. Co-evolution with flowering plants amongst bees and pollinating Diptera such as Tabanidae and Nemestrinidae has led to endemism in the Fynbos and Succulent Karoo biomes, with some species being restricted to relatively small areas. In general, the other biomes have been less well assessed than the Fynbos in terms of insect endemism.

Accurate general assessments of levels of endemism for South African insect orders or lower taxa are not readily available, but some estimates have been made. For example, 21% of Odonata are endemic to South Africa, and for the bees, 11% of the genera and just on 50% of the species are endemic (Kuhlmann 2009). The narrow endemism of some lower taxa is well documented, and is most pronounced amongst flightless taxa. The wingless stag beetle genus *Colophon* of the Lucanidae is a prime example, where each of the 17 species are restricted to a single mountain peak in the Western Cape. The grasshopper family

Fig. 11.3 The Cape Floristic Region is rich in localized endemic species, such as the Cederberg Rock Katydid *Cederberginiana imperfecta*, a large-sized (35 mm body length) species confined to cracks in rock faces in one part of the Cederberg Mountains (Photo Piotr Naskrecki)

Lentulidae is also wingless, and has high levels of endemism. Most of the endemic species identified by Picker and Samways (1996) on the Cape Peninsula were non-insect invertebrates or apterous insects, suggesting that mobility is a key factor in endemicity (Fig. 11.3).

11.5 State of Insect Taxonomy in South Africa: Historical Thrusts

The study of South Africa's insect fauna dates back to the days of Linnaeus when many specimens were collected from the Cape. Some of the earliest specimens were collected from Cape Town by M. Grubb in 1764, although Linnaeus apparently stated already in 1752 that "there is no place in the world with so many plants, animals, insects and other wonders of nature as Africa, and it seems as if they have been concentrated to the Cape". He therefore sent a number of his students to collect in the Cape, including C.P. Thunberg and A. Sparrman, between 1772 and 1775. Insects were among the material collected, and deposited in various Swedish institutions such as the University of Uppsala. Both these collectors also described insects from the Cape, and several other Swedish naturalists continued collecting and describing South African insects in the 1800s. This trend continued in the 1900s, with the Swedish South Africa Expedition by the Zoological Institute in Lund between 1951 and 1952 (Hanström et al. 1955). While this expedition was undertaken mostly by Per Brinck, Gustav Rudebeck and Bertl Hamstöm, they were joined at times by South African scientists (although no details are provided about these in the volumes about the expedition).

As a result of the Lund Expedition, the first comprehensive account of the insect fauna of South Africa was provided in the South African Animal Life series, which was published as 12 volumes between 1955 and 1965, by various local and international specialists, using the Swedish South Africa Expedition material as the basis for the chapters, although in most cases the coverage was not limited to this material. Alarmingly for several taxa, this remains the last revision of the fauna as a whole!

Other historical, comprehensive surveys for insects are not well documented. Taxon-specific surveys have been undertaken in the past, most notably the termite survey, and the Australian CSIRO Dung Beetle Research Unit survey of South Africa between 1971 and 1986 to identify suitable species for dealing with large quantities of livestock dung in their country. Surveys and monitoring of four locust species with pest status were carried out over several years by the Agricultural Research Council (ARC). Even comprehensive insect surveys of particular parts of South Africa are uncommon in the literature.

Stuckenberg (1964) provided the first overview of insect diversity in South Africa, and this was followed by a comprehensive review edited by Coaton in 1974, with accounts of each order contributed by a taxon expert. The challenges for insect taxonomy in South Africa identified in that publication have been repeated since then by several authors (e.g. Holm 1975; Scholtz 1999).

The standard text for insect diversity in southern Africa remains Scholtz and Holm (1985), which was republished in 2008. This work provides a description and keys for most insect families, as well as biological information, and an estimate of diversity where this exists. The fact that no revision of the text was carried out when the book was republished may be a reflection of capacity and resources, or perhaps the lack of substantial progress or change in taxonomic studies and understanding of insects in southern Africa. Guides to the freshwater insects of South Africa were published as a series of books by the Freshwater Research Commission (e.g. Day et al. 2002; De Moor et al. 2003; Stahls and De Moor 2007), but these are focused more on identification than revision of taxa.

Trends in insect taxonomy have been largely dependent on activities by individuals based at universities (such as dragonflies and cicadellids at the Entomology Museum, Stellenbosch University) or other research institutes, predominantly national and regional museums. Historically at museums, established taxonomists trained a successor, who continued the taxonomic work on a particular order or even family. In a few cases, research groups, or institutions have focused on a particular taxon. For example, the KwaZulu-Natal Museum has, since the 1960s, employed two to three taxonomists working on Diptera, and this became an established centre for the order, attracting international researchers to work on the collections. The Iziko South African Museum in Cape Town has had a long-term focus on Hymenoptera, while the Ditsong National Museum (ex Transvaal Museum) has focused on Lepidoptera and Coleoptera. Another approach has been that of Professor Clarke Scholtz at the University of Pretoria, who established and maintained a research team comprising postdoctoral associates, postgraduate students, and international visitors over a 30 year period, working on the Scarabaeinae (Scholtz et al. 2009). In other institutions, a single taxonomist specializing on an order, has developed a collection, but there has been little continuity over time in the research. The Plant Protection Research Institute of the ARC under the Department of Agriculture (now the Department of Agriculture, Forestry and Fisheries) has for many years had an Entomology section, forming the largest concentration of insect taxonomists in South Africa. This is still the case, and while the rationale for the unit has been agricultural research, the taxonomists there have published much more broadly than agricultural pests.

There have been no national initiatives to develop insect taxonomy in general, or in terms of specified taxa, although such strategies have been highlighted by authors of overviews of insect taxonomy for South Africa. There have been several taxonomists who have made major contributions over many years to knowledge of the insect fauna. Coaton (1974) provides a valuable historic insight into taxonomists who made major contributions to each order and in some cases, family of insects. International taxonomists have been a feature of South African taxonomy, and their contribution has been, and still is critical to the development of knowledge of the fauna.

Today there are only 20 taxonomists working on insects in permanent posts in South Africa, and about ten more who are retired, but who continue to publish taxonomic work, and in some cases to curate collections. There are also at least five individuals not employed as professional entomologists who are productive in terms of taxonomy but who do this research in their free time. Only three of the permanent staff are based at universities, which is a major concern for the future of insect taxonomy in South Africa. Also, considering South Africa may have as many as 250,000 insect species, this means about 10,000 species per permanently employed taxonomist! South Africa therefore needs to increase its current investment in taxonomic research by at least an order of magnitude if international biodiversity targets are ever to be met.

11.6 Insect Collections

An assessment of South Africa's entomology collections in 2009/2010 estimated that 10.5 million insect specimens, including 74,830 type specimens (holotypes and paratypes), are housed in formal collections in South Africa. This assessment excluded private collections, which must hold at least another million specimens. The number of South African specimens in European and North American institutions may be even larger than the number held within the country, given the length of time and extent of collecting by such institutions in South Africa.

Insect collections in formal institutions currently fall mostly under state controlled and funded museums, although there are less extensive collections in a few universities. However, in most cases university collections are more oriented towards teaching and comprise mostly material collected by undergraduate students (Rhodes University, University of the Witwatersrand for example), with large amounts of material not identified beyond family level. Stellenbosch University holds an insect collection comprising a reference collection of agriculturally important insects, as well as research material collected by postgraduate and undergraduate students. Exceptions to this general trend at universities are the research collection of Scarabaeinae housed at the University of Pretoria, and of dragonflies at Stellenbosch University. Most of the insect collections are held by six of the country's 11 museums and the Biosystematics Division of the ARC, which houses the so-called National Insect Collection. The largest collections are those of the Ditsong Museum, and the Iziko South African Museum, which hold between three and four million specimens each. A large proportion of material in the collections remains unstudied and unidentified at lower taxonomic levels.

Table 11.1 provides details of the formal institutions and their holdings in South Africa, as well as the extent to which the collections have been databased.

In terms of the state of the collections, the National Collection of Insects was recently moved from a run down and inappropriate building in Pretoria, where it had been housed for almost 50 years, to a new, custom-built facility on the outskirts of the city. The Iziko South African Museum insect collection has just undergone a complete re-organisation and checking process, which took almost 20 years to complete. Most of the collections face challenges with temperature, humidity and pest control, and in some cases, the prospect of running out of space in the near future is an additional problem. However, the main problem is that of staffing, with these vast collections being curated and researched by a total of 18 in-house scientists/curators and 17 technicians. This equates to 35 personnel for 10.5 million specimens or 300,000 specimens per person.

11.7 Regional Assessments

11.7.1 Butterflies

The butterfly fauna of South Africa has been well studied over many years, and the group is taxonomically well known, with a few minor issues unresolved. In addition, the distribution of species is also relatively well studied, thanks to the combined efforts of professional lepidopterists and the members of the Lepidopterists' Society of Africa. In the recent South African Butterfly Conservation Assessment (SABCA), over 400,000 records for the 671 species have been included in the database to be used for the conservation assessment of species. The details of this project, and for butterfly assessments in general are covered in Chap. 12.

Table 11.1 Insect collections held in state-funded collections and universities in South Africa

Institution/Collection	Taxonomic coverage	Size: number of specimens	Unaccessioned: estimated number of specimens	Growth (% in last 10 years)	Number of type specimens	Databased %
East London Museum	Butterflies: ex-private collection	1,543	0	0	0	100
Natal Museum	Diptera mainly, also Heteroptera, Mecoptera, ex-private collection Lepidoptera; other orders mostly reference for eastern region of SA	530,000	4,000	7	6,750	80
National Museum	Entomology: Coleoptera (153,658), Diptera (26,735), Hemiptera (7,670), Thysanura (4,038), Lepidoptera (3,645) and Hymenoptera (2,711)	201,124	2,000	10	1,801	60
Stellenbosch University	Insects: all orders, mainly Lepidoptera, Cicadellidae, Odonata, mainly of Fynbos	12,000	10,000	20	300	0
Iziko Museum	Insects: Lepidoptera (50,000); Coleoptera (200,000); Hymenoptera (250,000); Diptera (65,000); all other orders, also mixed samples	3,500,000	221,679	200	20,000	30

Agricultural Research Council, Biosystematics Division	Insects: Coleoptera (750,000); Hymenoptera (97,500); Hemiptera (123,870); Thysanoptera (84,000); Diperea (47,500); Orthoptera (42,200); all orders represented	1,228,390	1,032,312	20	4,000	45
University of Witwatersrand	Various insects; private collection of butterflies donated, student collections	2,500	5,000	10	0	60
Skukuza, Kruger National Park	Various insects, most from Kruger National Park	10,000	200	2	11	60
University of Pretoria	Scarabaeidae mostly	30,000	100,000	50	87	5
National Health Laboratory Services/Vector Control Reference Unit	Medically important arthropods, mostly Diptera (Culicidae, Ceratopogonidae, Simuliidae), Siphonaptera, Phthiraptera, Heteroptera (bed bugs mainly)	60,000	1,000	1	3,957	28
Ditsong National Museum of Natural History	Lepidoptera	1,250,000	40,000	2	6,500	10
Ditsong National Museum of Natural History	Coleoptera	1,250,000	2,000	10	5,983	2.7

(continued)

Table 11.1 (continued)

Institution/Collection	Taxonomic coverage	Size: number of specimens	Unaccessioned: estimated number of specimens	Growth (% in last 10 years)	Number of type specimens	Databased %
Ditsong National Museum of Natural History	General entomology: all orders except Coleoptera and Lepidoptera	130,230	2,000	0.5	4,553	15
Albany Museum	Freshwater insects: mainly Ephemeroptera, Trichoptera and Simuliidae (also other freshwater invertebrates)	350,000	15,000	15	1,000	60
Albany Museum	Insects: mainly Hymenoptera, Coleoptera and Diptera, all orders represented	280,000	2,500	10	19,234	9
Durban Natural Science Museum	Insects: Coleoptera (33,694), Lepidoptera (44,863); Hymenoptera (5097); all other orders represented; mostly from KwaZulu-Natal	102,012	40,226	5	654	71
Total/Average		8,937,799	1,477,917	22.7% average	74,830	39.7% average

11.7.2 Dragonflies

Dragonflies have been extensively collected in South Africa over many years, particularly by E.C.G Pinhey, B. I. Balinsky and M. J. Samways. Pinhey (1984, 1985) provided an initial assessment, which has been followed in recent years by some biogeographical assessments (Samways 1999, 2008a) leading to quantitative conservation assessments (Finch et al. 2006; Simaika and Samways 2009a, 2010a). This work fed into a southern African regional assessment (Suhling et al. 2009), and even a pan-African assessment, which is in progress (Dijkstra et al. 2011).

11.7.3 Termites

The National Survey of Isoptera was carried out in South Africa and Namibia by the ARC National Collection of Insects from 1958, continuing for more than 20 years, contributing more than 35,000 samples, and covering almost every quarter degree square in southern Africa (excluding Botswana and Lesotho). The survey resulted in the revision of most of the major termite genera in Southern Africa mostly by Coaton. This means that the termites of South Africa are taxonomically relatively well known, and their distribution is better documented than most other taxa.

11.7.4 Non-insect Arthropods

The South African National Survey of Arachnids (SANSA) is a project currently being coordinated by the SANBI and funded through the Danish Government. SANSA was officially launched in 2007, but it has built on an initiative driven for several years through the National Collection of Arachnids at the ARC, which is implementing SANSA. The SANSA project covers all non-acarine arachnid orders, with the main focus on the spider fauna of South Africa. There are several aims, including survey of neglected areas to improve knowledge of diversity and distribution, the development of an annotated checklist of spider species, including information on endemism and rarity which can be used at a later stage to carry out a conservation assessment of the species, training of postgraduate students in spider taxonomy and diversity studies, and finally, outreach and public awareness. The project has resulted in over 50,000 specimen records being consolidated, more than 130 new species being described, and more than 30 scientific papers being published.

11.8 Red Listing Activities

There have not been any major co-ordinated efforts to carry out Red List assessment of insects or other invertebrate taxa in South Africa, and Red Listing has occurred on an ad hoc basis, by groups or individuals for specific taxa (Samways 2002). There are currently 93 insects on the IUCN Red List, 86 of which are categorized as threatened, with two lycaenid species considered Extinct. Most of the assessments require updating, with the only valid assessments being those for the Odonata (Samways 2006a; Samways and Grant 2006a; Suhling et al. 2009). The butterflies form the bulk of the species on the list, but the assessments on the IUCN list were done in 1996. The butterflies of South Africa are currently being thoroughly assessed as part of the SABCA project, and a preliminary assessment was published in 2009 (Henning et al. 2009). The *Colophon* beetles and two ant species are also listed, but these assessments are outdated (Table 11.2). No other insects have been assessed, and there is reluctance on the part of experts to undertake this activity

Table 11.2 Red Listed arthropods and comments on status of assessments

Order/Family/Genus	EX	CR	EN	VU	Status
Coleoptera/Lucanidae/ *Colophon*	0	4	5	4	Needs updating; assessed in 1996
Lepidoptera/ Lycaenidae	2	2	5	55	Assessed in 1996, 2009
Odonata	0	1	2	6	Assessed in 1996, 1999, 2002, 2006 and 2009

Fig. 11.4 The Imperiled Katydid *Paracilacris periclitatus*, confined to one small patch of indigenous forest in KwaZulu-Natal, has been added by Corinna Bazelet to the IUCN Species of Day website to draw attention to the threats facing some South African insects (Photo Piotr Naskrecki)

because of the uncertainty in terms of populations and distributions for most insect species. There may also be some concern that Red Listing of insects could lead to major constraints in terms of obtaining collecting permits for research purposes. The power of having species formally assessed and listed, however, cannot be overestimated, and conservation authorities reviewing land use change applications do use Red Listed species to make decisions, or at least to request mitigation where threatened species will be affected. Updating and expansion of the Red List must be a priority activity for South African insects because it will make a major contribution to insect conservation. Helpful in this process is searching for new localities for threatened species using predictive modeling, a process that has been pioneered using the Karkloof Blue butterfly *Orachrysops ariadne* (Armstrong 2002) (Fig. 11.4).

11.9 National Issues

South Africa has well established and detailed legislation and strategies to conserve biodiversity. The *National Biodiversity Strategy and Action Plan* (NBSAP) was developed between 2003 and 2005 by the Department of Environmental Affairs and Tourism (DEAT, now known as the Department of Water and Environmental Affairs) to set out a framework and implementation plan for the conservation and sustainable use of South Africa's biodiversity, and the equitable sharing of benefits derived from the use of biodiversity. Some of the relevant activities proposed in the NBSAP include: (i) set quantitative national targets for all ecosystems and for threatened, endemic, indicator, flagship and high-value useful species, (ii) identify major gaps in our knowledge and understanding of biodiversity through a collaborative process, (iii) design collaborative programmes that fill these gaps, and ensure that biodiversity inventories and atlases meet the requirements of bioregional planning and monitoring, (iv) update South African Red Lists and implement a coordinated long-term programme to update these data regularly, (v) establish and maintain accessible data and information systems to inform strategy, action and reporting, and finally (vi) establish a monitoring and evaluation framework (including indicators and thresholds) for ecosystems and species, with a particular emphasis on those that are threatened. There are also activities that address raising awareness of the importance of biodiversity amongst parliamentarians, biodiversity education programmes and capacity development for the biodiversity sector. The challenge remains to effectively implement these activities, and much of the responsibility falls on SANBI to do this through the establishment of collaborations and partnerships with experts or relevant institutions especially for non-plant components of biodiversity. Past and current biodiversity planning initiatives, such as the National Spatial Biodiversity Assessment carried out in 2004 did not include insects, neither did a national conservation assessment of forests. The reason given for this omission was the lack of accessible, appropriate data sets. Given the state of insect collections and taxonomists available in South Africa, this group is likely to be omitted in future assessments, barring significant effective and strategic government investment.

The *National Biodiversity Framework* was published in 2009, and this document provides the implementation framework for the NBSAP. Sadly, taxonomy and research collections are not mentioned in this document, a situation which must be remedied in future revised versions in line with the high priority afforded taxonomy in the Conference of the Parties/Global Taxonomic Initiative recommendations of 2010 (http://www.cbd.int/doc/?meeting=cop-10). Globally the value of specimens and their associated data, and correct identifications and classifications are core to most conservation activities.

The *National Environmental Management Biodiversity Act* (NEMBA) was promulgated in 2004, and deals with many aspects of relevance to insect conservation, although insects (and invertebrates for that matter) are not mentioned. The Act also established SANBI, which was previously the National Botanical Institute, as an institute with an expanded mandate to deal with various aspects of not only plant, but all biodiversity. Included in this legal mandate is responsibility for promoting and coordinating taxonomy, responsibility for collections of dead animals, as well as coordinating of biodiversity information. The challenge to ensure that this expansion and change in focus, especially in terms of taxonomy and collections, does occur, with budgetary and capacity constraints and the problems with fragmented institutions over which SANBI has no direct influence, is being addressed but remains, even six years after the establishment of the Institute. Notwithstanding, the creation and use of the term 'biodiversity' nationally and internationally, gives hope that insect taxonomy in South Africa will now start to enjoy the attention that it deserves.

11.10 Reserve Networks

Much time and effort has been devoted in South Africa to systematic reserve selection, with insects rarely having been involved. As a start, however, termites have been used, along with other, non-insect, taxa, in a sub-regional assessment to determine how much land would be needed to effectively conserve biodiversity (Muller et al. 1997; Reyers et al. 2002). Dragonflies have been quantitatively assessed relative to the national reserve network, with an assessment of how well these reserves are catering for this group (Simaika and Samways 2009a). The results are largely encouraging, although some species such as the highly threatened damselfly *Chlorolestes apricans* are not known from any reserve (Fig. 11.5).

11.11 Special Insect Reserves

Only butterflies have received attention for special reserves devoted to specific taxa. Four threatened butterfly species have had reserves proclaimed (Henning et al. 2009), with initial indications that such small reserves can be effective,

Fig. 11.5 One of South Africa's rarest and most threatened insects, the Basking malachite *Chlorolestes apricans*, and still not known from any reserve (Photo: Michael Samways)

so long as the biology of the focal species is well known and that the management of the reserve is done appropriately (Deutschländer and Bredenkamp 1999; Lu and Samways 2002; Samways and Lu 2007; Edge et al. 2008a, b). Some insect species, while not having reserves specifically proclaimed for them, are nevertheless considered important conservation subjects in general reserves. Best known among these is the highly threatened dung beetle *Circellium bacchus*, restricted to the Addo Elephant National Park, Eastern Cape (Scholtz and Chown 1993).

11.12 Non-governmental Organizations and Citizen Entomologist Activities

The Entomological Society of Southern Africa really started to be involved in insect conservation activities in a major way with the 13th Congress of the Society in Pietermaritzburg in 2001, and a subsequent Special Issue of the Society's journal devoted to arthropod diversity and conservation appearing in 2002 (McGeoch and Samways 2002). The only insect taxon to have a local regional society is the Lepidopterists' Society of Southern Africa, with a strong emphasis on conservation. It was also instrumental, along with the then Foundation for Research Development, in producing the first South African insect Red Data Book, which was on butterflies (Henning and Henning 1989). Then 20 years later appeared the update, also largely driven by the Lepidopterists' Society (Henning et al. 2009).

There have been limited major initiatives to increase public awareness about the importance of insect conservation, but interest in invertebrates from the public has been shown. A study on tourists' attitudes towards including invertebrates in guided tours in game reserves in South Africa showed that the public does have an interest in learning about insects, and 95% of people reacted positively to the potential inclusion of invertebrates in tours (Huntly et al. 2005). Citizen scientists have made a significant contribution to both the SABCA and the SANSA projects through submitting photographs with data to the virtual museums of these projects. The effectiveness of using non-specialists in carrying out insect surveys was shown by the involvement of a wide range of the public in an Earthwatch project surveying invertebrates in Mkuze Game Reserve (Lovell et al. 2009) (Fig. 11.6). Involving local rural communities has played an important role in the practical conservation of the Karkloof blue butterfly *Orachrysops ariadne* (Louw and Armstrong 2010).

While there have been several papers and books devoted to increasing conservation awareness in South Africa, few have considered insects specifically. One very comprehensive book is *Bring Butterflies Back to Your Garden* (Botha and Botha 2006), which is packed full of information for citizen scientists. Awareness trails for dragonflies have been developed, with a scientific analysis of their effectiveness (Suh and Samways 2001, 2005; Niba and Samways 2006a). One of the most influential publications for both professional entomologists and citizen scientists was the appearance in 2002 of *Field Guide to Insects of South Africa* (Picker et al. 2002b). While not aimed necessarily at conservationists, the great influence of the book is that it has drawn attention to many conspicuous insect species in the country through an excellent collection of photographs, and so has played a major role in increasing awareness of insects, a first step to their conservation.

Fig. 11.6 The local community and Ezemvelo KZN Wildlife officers undertaking an egg count of the Karkloof Blue butterfly *Orachrysops ariadne* (inset) towards its conservation management (Photo Adrian Armstrong, inset Sheng-Shan Lu)

11.13 Insect Conservation Education

Insect conservation has been taught as a subject at the University of KwaZulu-Natal since the late 1980s, as part of the then Invertebrate Conservation Research Centre. It has also been taught as a stand alone course, Insect Conservation Ecology, at Stellenbosch University since 2002, and by 2010 attracted 41 students. During this course, students undertake a practical project of their choosing, and each year some students choose to undertake an insect conservation education project. Outcomes have involved information charts and potential handouts for learners. One student even took the initiative and introduced a course on insect conservation to learners and obtained feedback on interest in the subject. What arose was that learners are really interested in insect conservation, and arguably more interested than adults, a point that came out in development of the dragonfly awareness trail mentioned above (Suh and Samways 2001). Other universities also include insects in their curriculum on conservation, most notably Rhodes University, University of Pretoria, University of Venda and University of the Free State.

11.14 Important Landscape Initiatives

While, historically, there has been some focus on the conservation of specific insect species, it is really the coarse filter, landscape approach that historically has given most positive and active insect conservation a major boost. This has involved focus on certain physical areas of major biodiversity importance, such as Table Mountain (Picker and Samways 1996; Pryke and Samways 2008, 2009a, b, 2010) and neighbouring areas (Donaldson et al. 2002), the Cederburg (Botes et al. 2006a, 2007), as well as Tsitsikamma (Simaika and Samways 2010b) in the Cape Floristic Region (Giliomee 2003), the Karoo (Gess and Gess 1993), semiarid and savanna (Blaum et al. 2009), the Drakensberg (Samways 1990; Armstrong and van Hensbergen 1997; Uys et al. 2009), and savanna game reserves (Clark and Samways 1996; Rivers-Moore and Samways 1996; Stewart and Samways 1998; Samways and Kreuzinger 2001; McGeoch et al. 2002; Botes et al. 2006b and Lovell et al. 2007, 2009).

This landscape approach has also involved focusing on certain ecosystems, such as reservoirs (Samways 1989; Steytler and Samways 1995; Osborn and Samways 1996; Samways et al. 1996), and on ecotones, both terrestrial (Ingham and Samways 1996) and aquatic (Samways and Stewart 1997). This has involved understanding the effect of impacts so as to address insect conservation appropriately. Such impacts include the structure of the planted landscape (Samways and Moore 1991; Wood and Samways 1991; Magagula and Samways 2001), impact of grazing – both by indigenous and domestic livestock (Rivers-Moore and Samways 1996; Samways and Kreuzinger 2001; Gebeyehu and Samways 2003), and of fire (Chambers and Samways 1998). This has led to some specific restoration activities, both of riparian zones (Samways and Steytler 1996) and of grassland landscapes (Gebeyehu and Samways 2002). An additional conservation thrust has been a focus on the very unusual arthropod fauna in the ancient sandstone caves of Table Mountain, Cape Town, and which receive strict protection (Sharratt et al. 2000).

11.14.1 Working for Water Programme

The Working for Water Programme is a national initiative to remove invasive alien plants that are having a great impact on hydrological processes. It was also instigated to provide short term employment and training for unskilled unemployed people. While biodiversity conservation was not initially a main reason for the initiative, it soon became clear that biodiversity, and especially dragonflies, were being dramatically affected by invasive alien trees (Samways and Taylor 2004; Samways 2006b), while also receiving major benefit from their removal (Samways et al. 2005; Magoba and Samways 2010; Samways and Sharratt 2010), even across wide geographical areas in the country (Samways and Grant 2006b). Alien trees had a lesser effect on benthic macroinvertebrates in general, while clearing of these aliens was not necessarily beneficial for all species, even some narrow range endemics (Samways et al. 2011). Under this programme and with dragonflies being so sensitive to changes in water and bank conditions a Dragonfly Biotic Index was developed (Samways 2008a; Simaika and Samways 2009b, 2010b) for monitoring rivers in particular, and as a more sensitive monitoring tool than the South African Scoring System, which uses higher taxon levels of macroinvertebrates (Dickens and Graham 2002).

11.14.2 Ecological Networks

Large-scale ecological networks are interconnected corridors and nodes at the landscape level to mitigate the impact of human use of the landscape, especially for agroforestry purposes. Some sectors of the South African forestry industry, especially under the stewardship of the large company Mondi, have committed a third of the landscape for mostly conservation in the form of ecological networks (Samways 2007). These networks are also intended to maintain ecosystem services, which includes insects as part of that package (Samways et al. 2010). These ecological networks have been shown to have substantial benefit for butterflies (Pryke and Samways 2001, 2003) and for arthropods on flowers (Bullock and Samways 2005). Mesofilters (mesoscale features and areas) are important, including that of hills for hilltopping behaviour (Lawrence and Samways 2002).

11.15 Insects and Ecosystem Services

Although insects are undoubtedly an integral part of the fabric of life, fulfilling a multitude of ecosystem functions (Wilson 1992; Grimaldi and Engel 2005), globally there has been scientific interest in only a few of these functions in terms of their benefit to humans. The recent conception of the field of ecosystem services – goods and services provided by biodiversity and/or ecosystems that benefit the human race (De Groot et al. 2002) – has emphasized pollination, pest control and nutrient cycling by insects as key services (Losey and Vaughan 2006). Clear distinction, however, has to be made between the important ecosystem functions that insects provide, and those that are of value to mankind *viz. bona fide* ecosystem services (see Simaika and Samways 2008). For example, a recent review of the important ecological functions that dung beetles (Scarabaeinae) perform, identified eight types of functions while only three (prevention of range fouling, suppression of livestock pests and prevention of nitrogen loss) are currently recognised as ecosystem services (Nichols et al. 2008). This is not to say that the documented number of insect ecosystem services could not grow rapidly in the future, it rather indicates either a lack of valuation of these functions, or that the beneficiaries of these functions have not been identified. Another potential pitfall is to classify all processes regardless of their context as ecosystem services. Pollination is an important ecosystem process or function, but only crop pollination qualifies as an ecosystem service, while pollination of plants in natural ecosystems is not. For conservation activities that use ecosystem services as motivation, both these distinctions are important to ensure credibility and avoid circular reasoning. If maintenance of plant biodiversity through pollination is seen as an ecosystem service, it means conservation is motivating for the conservation of pollinators and their habitat because they rely on these to exist. This is not to say that in future people will not pay for the conservation of fauna and flora based on cultural services, but until such links are formally identified, such arguments will be counterproductive. An example of the potential services which are to be identified is Mayer et al. (2006) who quantify the impacts of disturbance on monkey beetles (Hopliini) that pollinate palatable indigenous forbs that are important forage plants for livestock. These insects thus perform an ecosystem service of pollination of valuable grazing species for pastoralists, although not specifically presented in the paper as such.

In South Africa research on ecosystem services in the field of entomology is new to the current decade. Although goods available from insects, such as food or silk fibre have been studied in detail before the creation of ecosystem services terminology (Scholtz 1984; Brandon and Bannister 1993; Styles 1994; Rebe 1999; Miller and Rogo 2001; McGeoch 2002; Veldtman et al. 2002), regulating services originating from insects have only recently been studied in South Africa. SANBI launched the Biodiversity and Ecosystem Services Programme in 2007 which has focused on ecosystem services that are likely to depend on biodiversity, especially in terms of agricultural production. Pollination has been an obvious departure point, due to global interest in pollinator declines (see Allen-Wardell et al. 1998; Biesmeijer et al. 2006). Internationally crop pollination ecosystem services has received the lion's share of scientific interest in insect services, with over 60 data papers either explicitly or implicitly dealing with this ecosystem service between 1990 and 2009 (Veldtman and Colville, personal communication 2011). As part of this global pollinator initiative, SANBI acts as the lead in South Africa in a Global Pollinator Project including six other countries, namely Brazil, Ghana, Kenya, Pakistan, India and Nepal (www.fao.org/agriculture/crops/). Three commercial South African crops have been identified for study, namely apples in the Western Cape, sunflower seed in the Springbok Flats of Limpopo, and hybrid seed onions in the arid Klein and Greater Karoo. In addition, studies on the pollination of mangos in the sub-tropical areas of Limpopo and Rooibos (an indigenous species, *Aspalathus linearis*, used for tea) in the West Coast Mountains have also been undertaken. Currently, Allsopp et al. (2008), Shenkute (2009), Tesfay (2009), and Carvalheiro et al. (2010) represent the only published information on pollination ecosystem services in South African agricultural systems, although this number will undoubtedly increase rapidly in the near future due to the current national and global interest in ecosystem services. Other South African studies quantifying insect ecosystem functions in the context of ecosystem services include Brown et al. (2010), which investigates the role of dung beetles in improving the hydrological properties of rangelands.

Although the use of ecosystem service arguments to motivate for insect conservation is still very much in its infancy, especially in South Africa, the potential of combining the ecosystem service approach with traditional, reserve-based, and other current insect conservation initiatives, such as within-farm insect conservation (Samways 1994), is promising. In addition, given the hyper-abundance, poor taxonomic state of many insect groups and the difficulties of collecting and identifying this hyper-diversity, as well as important positions insects occupy in food webs, a process driven approach, rather than a species focus approach is most likely to make conservation actions plausible and successful in the long-term. Greater entomological focus (training and research) should be directed under the flag of ecosystem services; readily accessible sources of funding from agriculture and related industries being an obvious advantage.

11.16 Insect Conservation and Biological Control

Invasive alien weeds have become an increasingly important threat to biodiversity in South Africa. In response, weed biocontrol has been a particularly active field of endeavour. A landmark publication was the overview *Biological Control of Weeds in South Africa* (Hoffmann 1991), followed by South Africa hosting the IX International Symposium on Biological of Weeds (Moran and Hoffmann 1996), and a subsequent Memoir of African Entomology (1999, Memoir No. 1) on the biological control in southern Africa between 1990 and 1999, consisting of 20 papers.

Insect conservation and biological control are however not related fields as both have very different goals. With insect conservation a key paradigm is the preservation of extant insect biodiversity, usually best achieved by maintaining the ecological processes while preventing ecological homogenisation. Classical biological control of weeds is achieved by releasing the natural enemy (herbivore) of a plant that has become invasive outside its natural range, usually assumed to be the result of enemy release or lack of competition with its congeners. It is important to consider that if an agent is released that cannot reduce the density of the target weed, the agent which is also a alien organism may become very abundant. Previously it has been illustrated that these conditions are conducive to the forming of non-target associations and potential impacts on native insects. For example, Carvalheiro et al. (2008) pointed out that through the process of apparent competition, where an agent and native species from the same family (Tephritidae) share a parasitoid species, the native dipteran seed herbivore community declines, with some species going locally extinct, especially where the agent was abundant. Novel associations may also complicate pest control management, where secondary links to an abundant biocontrol agent may create a resource niche for generalist herbivores (such as moths). Seymour and Veldtman (2010) have now documented the first case where an agricultural pest, *Thaumatotibia leucotreta* (false codling moth), can complete its life cycle on resources derived from the gall-inducing rust fungus (*Uromycladium tepperianum*) released against *Acacia saligna*, the moths being especially abundant near citrus orchards. It is generally recognized that biocontrol of invasive weeds like Australian Acacia need to be targeted simultaneously, to prevent one species simply replacing the invasive biomass of the controlled species (Moran et al. 2005). This however, means that we are likely to see even more alien insect species introduced to control invasive weeds. South Africa may thus in future not just resemble Australia in terms of these plant species, but also their accompanying insects! By only releasing agents with the definite ability to effectively reduce the target weed's density, the potential impact of such introductions will be reduced.

As regards insect biocontrol, there are no recorded examples of where an introduced insect natural has had a permanently adverse impact on an indigenous South African insect species. However, in a survey by Prinsloo and Samways (2001), only seven of the 45 species of chalcidoid biocontrol agents introduced into South Africa were found to be monophagous, suggesting that there should be on-going caution surrounding, and screening of, potential exotic biocontrol agents. Interestingly, there is also the situation in South Africa where certain biocontrol agents have assisted conservation efforts. The exotic scale pest *Aonidiella aurantii* infests indigenous trees such as *Rhus* spp. and *Trichilia* spp., and is kept at low levels by the indigenous parasitoid *Aphytis africanus*, as well as the exotic ladybird *Chilocorus nigritus* (Samways 1988).

11.17 Future Perspectives

11.17.1 Taxonomic Expertise

The problems associated with the available capacity to deal with the large insect fauna of South Africa have been raised since Stuckenberg's (1964) review of entomology in South Africa. His concerns were echoed by Coaton's (1974) report, and have been repeated by several authors since then (Scholtz 1999) as well as this chapter. The problems of insufficient capacity to cover the fauna are by no means unique to South Africa (Winston and Metzger 1998; Hopkins and Freckleton 2002). Scholtz (1999) pointed out that it has taken over 250 years to document perhaps only half of the insect species of South Africa, and with the rapid rate of habitat alteration and loss, the prospects of ever completing the task before probable extinctions seems impossible. Undoubtedly, some form of strategy to deal with the problems associated with the lack of capacity is required. SANBI appointed a Director of Zoological Systematics and Collections at the beginning of 2009 and the role of this position is largely to develop and guide implementation of a national strategy, as well as the co-ordination of animal taxonomy and collections. This is a massive challenge given that animal taxonomists are scattered across about 30 institutions in South Africa (as well as many international institutions), and that funding is not only very limited, but also fragmented. The South African Biosystematics Initiative (SABI) is funded through the Department of Science and Technology and provides grants for research, for postgraduate studies postdoctoral grants and international travel grants for postgraduate students in the field of taxonomy. While the programme has been successful in terms of rejuvenating interest in taxonomy amongst postgraduate students in some fields, entomology has not attracted as many new taxonomists as are required. The reasons are complex; it has been suggested that students do not see traditional insect taxonomy as an attractive career because there are insufficient posts for graduates to fill, and salaries are perceived as being poor. Changing this perception or circumstances should be a priority if insect taxonomy is to thrive in South Africa. There are, however, several initiatives that could at least assist with capacity problems. Co-ordination of all existing information and making this accessible through annotated checklists and a South African node of the Encyclopedia of Life (EoL) are two ways to ensure that at least important gaps are identified, that taxonomists starting work on a group do not have to spend time gathering and compiling information from scratch, and that they do not have to spend time providing information when it is required. Having taxonomic information, linked to biological and distribution data, knowing which taxa are important for ecosystem services, and this information being accessible on the internet, highlights the contributions of taxonomists, and the value of taxonomy, and will hopefully mainstream the inclusion of insects in conservation initiatives.

The Barcode of Life project also needs to be seriously considered as an aid to insect taxonomy in South Africa. Several individuals have already started providing specimens to the International Barcode of Life for barcoding, and plans are underway to co-ordinate and stimulate barcoding activities in South Africa. While there has been some criticism of barcoding from taxonomists, it offers enormous potential to assist with identification of species, freeing up taxonomists time to make progress with describing and naming new species or revising taxa, and will also help for taxa where expertise is unavailable. In addition, in many cases barcoding offers an immediate solution for documenting species (even if only by their molecules) in the face of rapid biodiversity extinction. The combination of biotechnology, biodiversity information management and traditional taxonomy may also be far more attractive to young graduates than traditional morphological taxonomy on its own and should receive more support.

11.17.2 Collections

The entomology collections, just like taxonomic capacity, have faced the same globally experienced problems of inadequate resources and fragmentation for at least 45 years, and recommendations from several reports have not been implemented. The main obstacle to any progress with improving the situation for insect collections is probably the lack of co-ordination, with no single body representing institutions falling under different governance structures, from municipal, to provincial and national, and under four different national government departments (Agriculture, Forestry & Fisheries, Arts & Culture, and Science & Technology, as well as Higher Education) notably none falling under the Department of Environmental Affairs. The National Research Foundation (NRF) of South Africa, in collaboration with SANBI carried out a very comprehensive assessment of collections stemming from concerns raised by a number of stakeholders. The report on this assessment includes several possible scenarios for the future of the collections. These scenarios will need to be discussed with various role players, and their implementation costed, before final decisions can be made. The minimum intervention could provide a formal network of collections, with common objectives, standards and procedures. However, more radical actions may provide greater impact, and amalgamation or rationalization of smaller collections may be more successful in terms of ensuring the sustained security of the collections. Amalgamation will also provide a critical mass of scientists, and thus a more stimulating environment than entomologists working in isolation at different institutions. The positive indications are that government appreciates the collections, and is concerned about their future.

The South African Biodiversity Information Facility (SABIF) was established as a node of the Global Biodiversity Facility (GBIF) five years ago. This initiative has funded the databasing of several million specimens, and has made these data available through the SABIF website. They are also involved in getting the data quality improved, as well as standardising the software used for databasing. Ideally mobilisation of the data from collections will mean that this is accessible for conservation assessments, environmental impact assessments and conservation planning.

11.17.3 Insect Conservation Training and Mainstreaming Insect Conservation

While ‘conservation biology’ or ‘biodiversity conservation’ is part of the curricula of most universities in South Africa, there is not necessarily a specific focus on insect conservation. However, there is an ever-increasing trend for insects to be mainstreamed into environmental conservation (see below). A natural extension of this is that insect conservation is forming an increasing part of such curricula, especially as the 'second generation' of graduate students take up professional positions in universities, which recently includes University of the Free State and University of Venda. Meanwhile, students at Bachelor's, Master's and Doctoral levels are being trained at Stellenbosch University, where conservation and area-wide pest management (see below) are taught in the same department, the Department of Conservation Ecology and Entomology. Training is also taking place within the government organizations, with South African National Parks leading the way. In addition, there is another important initiative emanating from Stellenbosch University, and that is the direct linkage between primary research activities and the corporate sector. As so much land is in private hands, this is a logical way forward, with insects for instance now being the prime focal organisms for the Mondi Ecological Network Programme. Mondi makes a donation to support a post-doctoral Researcher Associate and research students. The research is crafted by the university sector but implemented by the corporate sector, creating a feedback loop, where design and management of the landscape are changed following research findings, and then new research directions arise out new demands from field practice. This process is partly driven by the need for Forest Stewardship Council certification, enabling access to European markets for the timber products. This interaction between the two institutions not only involves the setting of conservation goals, but also monitoring the success of these activities. The success of this forestry sector/university interaction has been so successful that it is leading to other partnerships, including with the sugar, wine and deciduous fruit industries. To restress, so much land is under corporate stewardship that much insect conservation can be achieved by this landscape approach. Yet such an approach also recognizes the value of reserves and various other design and management approaches, which have now been synthesized into a conceptual model, the so called synthetic management approach (Samways 2007). Many of these initiatives have gained acceptance as they feed directly into *South Africa's National Biodiversity Strategy and Action Plan* (2005).

11.17.4 Area-Wide Integrated Pest Management – Conservation Enters Integrated Pest Management Thinking

Integrated pest management in South Africa is going through a major change in philosophy and technology. Traditionally, pest management was focused on the production area itself, but with the realization that many pests are indigenous and increasing concern for conservation of wildlife, coupled with increasing human health and environmental awareness by European importers of produce, there has been a recent surge in research that not only reduces reliance on pesticides but also considers the whole landscape. Crops leading the field are deciduous fruit, citrus, sugar and vines. There has also been a growing interest in organic farming

(Gaigher and Samways 2010), but it became clear during this research that issues surrounding organic farming, such as recycling of nutrients and biodynamic approaches, are not necessarily addressing conservation of invertebrates, simply because the agricultural landscape is so transformed. Interestingly however, Magoba (2010) found that the footprint of invasive alien plants is not as great as that of even traditional vineyards on soil surface arthropods. Assessment of the production landscape and its improved development for biodiversity conservation (especially insects) and the conservation of ecosystem processes (thus including function and service) is a field that continues to develop.

11.17.5 Climate Change Initiatives

One of the first projects to model climate envelopes for a South African insect was that of Tribe and Richardson (1994) focusing on where the invasive alien European wasp *Vespula germanica* might spread. Samways et al. (1999) then studied global climate change using a modeling approach based on actual establishment or not, to determine to what extent climate change will be the main driver of altered geographic ranges among ladybirds. Climate alone was responsible for correct predictions of geographic range change in only a quarter of the species investigated, while for one species, climate had no effect. For most species, geographic range changes were determined by local factors such as microclimate, phenology, host type and availability, presence or absence of natural enemies and hibernation sites, in addition to climate.

While in South Africa there are little historic data of sufficient resolution to do much in the way of establishing the extent of change of geographic ranges with anthropogenic climate change, there is some information on some taxa to determine the potential for large-scale movement in the country (such as bees). However, the physiognomy and general climate of South Africa mean that there are great differences across the country, with for example predictable elevational ranges for dragonflies in the Western Cape and KwaZulu-Natal and the south-western Cape (although they differ between these two regions for species which occur in both), yet being more variable in the savanna regions. Furthermore, predicting how species will respond to global climate change must be seen against remarkably wide elevational ranges, at least in dragonflies, in El Niño-prone areas (Niba and Samways 2006b; Samways and Niba 2010), which leads to some species showing great expansions and then contractions in wet and dry years respectively (Samways 2010). The point from a perspective of global climate change is that there is a great amount of roughly decadal climate change which must be considered when observing and predicting range changes due to anthropogenic climate change. Nevertheless, at least among certain narrow-range endemic dragonflies recent and ongoing climate change is a distinct threat to the long-term survival of certain species which live in high elevation feeder streams (Samways 2008b), and the threat of climate change is likely to be synergistic with other impacts, especially that of invasive alien plants.

There is clearly much more to be done in this field, with for example large-scale ecological networks being investigated to determine whether they might act as a mitigation measure against global climate change.

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Chapter 12
Lepidopterology in Southern Africa: Past, Present and Future

Jonathan B. Ball

We have not inherited the world from our forefathers – we have borrowed it from our children.

[Kashmiri proverb (in: Rodes and Odell 1992)]

12.1 Introduction

The lepidopteran fauna (moths, skippers and butterflies) of southern Africa (including all countries south of the Zambezi-Kunene rivers) comprises about 9,000 species. This includes about 8,125 moth species in Southern Africa (Vári et al. 2002; Staude and Coetzer 2010, personal communication), with the largest families being the Noctuidae and the Geometridae [1,500 species in 221 genera (about 395 taxa having been added since 2002 (Staude and Coetzer 2010, personal communication))]. The ratio of described butterflies and skippers (about 875 species) to moths is about 1:9.3 for the subregion south of the Zambezi - Kunene rivers. Studies by Elliot Pinhey, Lajos Vári, Douglas Kroon, Martin Krüger, Arthur and Neville Duke, Hermann Staude, Jo Joannou and a few amateurs have added a considerable number of additional moth taxa in the last 30 years (for examples, see Joannou and Krüger 2009; Krüger 2002).

The butterfly fauna of South Africa consists of 662 species and 134 additional subspecies found in five families, 17 subfamilies and 153 genera (Henning et al. 2009). 51.6% of these taxa are endemic. The lycaenid component is one of the highest in the world, namely 49.6% (Ball 2006) and for the entire Afrotropical region, Lycaenidae comprise 43% of butterfly species (Williams 2010). For comparison, the equivalent percentages for some other geographical regions are as

J.B. Ball (✉)
Department of Zoology and Entomology, University of Pretoria,
Pretoria, 0002, South Africa
e-mail: jbball@iafrica.com

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follows: West Malaysia 38% (Corbet and Pendlebury 1992), Australia 36% (Braby 2000), Europe and Britain 27% (Heppner 1991), Neotropical and Nearctic 16% (Parsons 1999). Of the 397 South African lycaenid taxa, 89% appear to have a larval ant association (of these, the relationship is obligate in 74% and facultative in 26%). The Afrotropical total of butterfly and skipper species is presently 4,089 (Papilionoidea (3555) and Hesperiodea (534):Williams 2010, see also Ackery et al. 1995; Ball et al. 2009).

Part of the reason for the high insect diversity of this geopolitical area is the marked heterogeneity of its 20456 taxa of vascular flora, of which 13265 taxa (65%) are endemic (von Staden et al. 2009). This region hosts the world's richest temperate flora (Germishuizen et al. 2006), as one of only two countries exclusively containing three of the 34 global biodiversity hotspots, namely the Cape Floristic Region (6,200 vascular plant endemics = VPE), the Succulent Karoo (2,439 VPE) and the Maputoland-Pondoland-Albany Region (= Albany Thicket, Mucina and Rutherford 2006) (1,900 VPE) (Myers et al. 2000; Mittermeier et al. 2005; Rutherford et al. 2006; von Staden et al. 2009; Low and Rebelo 1998). The vegetation of this region has been divided into nine Biome Units (BUs), namely (in descending order of relative proportions of area): Savanna (32,5%), Grassland (27.9%), Nama-Karoo (19.5%), Fynbos (6.6%), Succulent Karoo (6.5%), Albany Thicket 2.2%, Desert (0.5%), Forests 0.3% and 'other' 2.3% (Mucina and Rutherford 2006). These BUs are further subdivided into 435 Vegetation Types – 34 of which are azonal (Mucina and Rutherford 2006). The Fynbos Biome is part of the global Mediterranean Biome, each component (also southwestern Australia, coastal Chile, California and the Mediterranean basin) having different evolutionary origins (Raven 1973). South Africa is Africa's richest and the world's third most species-rich country (Cowling and Hilton-Taylor 1994), to a considerable extent a consequence of the biotic riches of the Greater Cape flora. It appears that there was a major change in the make-up of this flora, due to increasing aridification between 10 and 5 Myr ago (Axelrod and Raven 1978; Hendey 1982). However the degree to which morphological, functional and floral (and thus invertebrate) species diversity occurred here, steered by adaptation to environmental changes, remains largely speculative (Ellis et al. 2006).

Some scientists contend that it is inappropriate to regard the Cape flora as a floral kingdom, for this would assume antiquity and stability (Cox and Moore 2005), and regard it simply as an interesting province within a larger floral kingdom (Cox 2001). However one views this area, it is the 'hottest' of the world's plant-diversity hotspots (Cowling and Hilton-Taylor 1994), hosting 52% of the floristic endemics of southern Africa. The soils of the Cape floral Kingdom have the lowest nutrient content (nitrogen and phosphorus) of the five different Mediterranean climate regions, even less than that found in the West Australian mallee (Houston 1993). The plant diversity of the Fynbos Biome is not mirrored by a similarly speciose faunal component, but there is very high endemism amongst the fairly poorly documented entomofauna (Jarvis 1979).

Probably no more than 2% of the flora of South Africa is specifically adapted to butterfly pollination. However, the large (combined wing diameter of 70–90 mm),

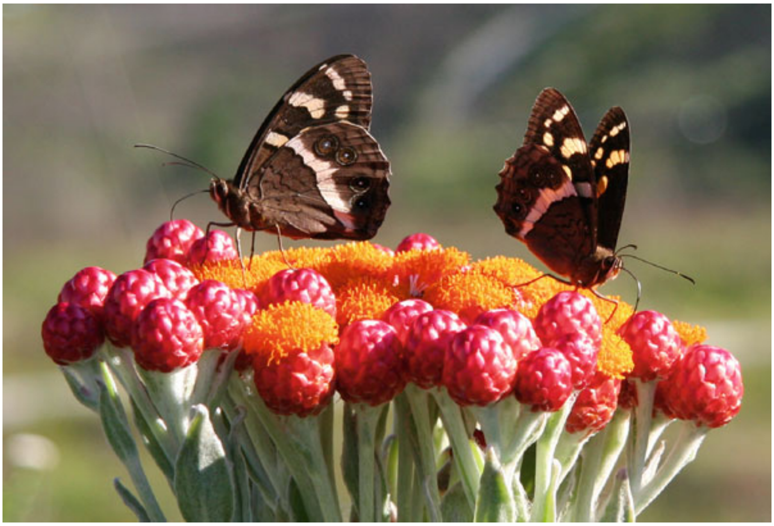

Fig. 12.1 *Aeropetes tulbaghia* (Mountain Pride) feeding on the composite flowerhead of *Syncarpha eximia* (Strawberry Everlasting) (Asteraceae) on the Outeniqua mountains in the Western Cape Province. This plant is found on the cool, moist, south-facing sandstone slopes in the 'southern Cape.' (Photo: Hermann Staude)

endemic (Western Cape to Zimbabwe), monobasic Mountain Pride satyrine *(Aeropetes tulbaghia*) is a keystone species, being the sole known pollinator of about 20 plant species (Marloth 1895; Johnson and Bond 1992; Johnson 1999) (Fig. 12.1). These plants mainly have large red or orange flowers, and include the iconic Red Disa, *Disa uniflora* (Orchidaceae), the Cluster Disa – *Disa ferruginea* (which does not produce nectar but which mimics the flowers of the sympatric, nectar-rich irid *Tritoniopsis triticea*), *Watsonia* spp. (Iridaceae), red-hot pokers *Kniphofia* spp. (Asphodelaceae), *Nerine* spp. (Amaryllidaceae) including the Guernsey lily – *N. sarniensis* (a Cape endemic), *Crassula coccinea* (Crassulaceae) and others. Many of the bird-pollinated plants of the fynbos also have red flowers. Most areas with flora dominated by insect-pollinated taxa have virtually no red flowers, so this satyrine – red (orange) flower/pollination relationship is an interesting local example of convergent evolution.

12.2 Use of Biome Units and Vegetation Types

The Biome Units of this region are highly disparate in size and lepidopteran endemicity. Boundaries between the Biome Units (BUs) (defined primarily on combinations of dominant life forms and secondarily on major climatic features), with their vegetation types (defined mainly on floristic criteria) range from very gradual to sharp. The number of vegetation types per biome also varies widely and is approximately proportionate to its floristic diversity (Mucina and Rutherford 2006).

Although Dennis (2010) has introduced the valid approach of the discernment of habitats founded on resources and biotic requirements, the ‘broad-brush’ utilisation of local biomes and vegetation units has its uses in focussing attention on areas and taxa at risk, conservation approaches and management as well as directing ‘ground sleuthing’ for further distributional data. Improved distributional data of rare taxa that occur at low frequency over a wide area have been obtained by modelling the available information and then identifying areas of suitable habitat that have not been sampled. This has been particularly valuable for butterflies in KwaZulu-Natal (Armstrong 2002, 2010).

About half (47.1%) the butterfly taxa occur in only one BU, 23.65 in two BUs and 14.5% in three BUs (Ball 2006). In contrast 15 butterfly generalist taxa are noted in all nine BUs. Some taxa are found in the ecotones between different BU and vegetation types. The disparity between the number of the 60 ‘At Risk’ butterfly taxa in the different BUs is to a large extent a reflection of suitable habitat and land use practices. 51.7% of these ‘At Risk’ taxa are found in the Grassland BU, 31.7% in the Fynbos BU and 6.7% in the Savanna BU. 81.7% of these ‘at risk’ taxa are found in just two BUs [Grassland (331,233 km²) and Fynbos (76,744 km²)] (Ball 2006). The smaller of the latter two BUs (Fynbos) has 66.7% of the Critically Endangered taxa compared with 16.7% for Grassland. An analysis of the ‘At Risk’ butterfly taxa helps to improve focus of conservation efforts. For example, three Vegetation Units each containing four ‘At Risk’ butterfly taxa (with major habitat degradation factors indicated in parentheses): Barberton Montane Grassland - Grassland Biome (plantation forestry, alien invasive vegetation), Knysna Sand Fynbos - Fynbos Biome (alien invasive vegetation, coastal housing development) and Swartland Shale Renosterveld - Fynbos Biome (agriculture – wheat growing, housing development, alien invasive vegetation). 55% (33/60) of the ‘At Risk’ butterfly taxa of South Africa have only one small area of occupancy of about 10 km² or less in one specific Vegetation Unit (Ball 2006; Henning et al. 2009). Most of the specific vegetation types have numbers of endemic insects and plants. Better synthesis of this data is needed.

12.3 The Presence of the Past

There are no authenticated lepidopteran fossils known from South Africa. However, the Birds River locality near Dordrecht in the Eastern Cape Province of South Africa, has yielded many (>500) insect and plant fossils in the Triassic Molteno Formation (MacRae 1999). The Molteno Biome was an extensive floodplain towards the centre of Gondwana. Two of these fossils possibly represent proto-lepidoptera (MacRae 1999). Moving forward, historical biogeography has shown that in the genus *Lycaena*, with its highly disjunctive distribution (mainly within the Holarctic Region), that the two South African taxa *Lycaena orus* and *L. clarki* are basally positioned on phylogenetic analysis – using two mitochondrial genes in the sequencing, COI and COII (de Jong and van Dorp 2006). These taxa are more closely related to *L. phlaeas* (with four Afrotropical races) than to the four New Zealand taxa. The first divergence (post-Gondwanan land mass fragmentation) of this widespread genus thus appears to have been between taxa from Africa and Eurasia (de Jong and van Dorp 2006). Larvae of all taxa of the Lycaeninae (apart from some probable secondary hostplant shifts in North America) feed on members of the Polygonaceae, a family purported to be not older than 37 million years (Wikström et al. 2004). The two South African *Lycaena* taxa are possibly relictual representatives of a previous more extensive sub-regional distribution.

A few southern African insect paintings by Khoisan artists exist, depicting bees (Woodhouse 1984). These are located in a few caves/rocky overhangs near Elliot in the Eastern Cape Province, as well as in Namibia, Zimbabwe and KwaZulu-Natal. In a number of these paintings, dancing human figures are noted near the rounded hives and buzzing white bees. European sailors began regularly rounding the Cape of Good Hope in the late 1500s in the rush for spices and Empire. In much of Africa there then began a cycle of 'explorer, trader, missionary, soldier, explorer, and so on' (D'Abrera 1997). It was the plants of the Cape that were first documented. The illustrated books by James Petiver in *Gazophylacii Naturae et Artis*, published from 1702 to 1709, show a number of specimens of Cape fauna and flora, including one of the first depictions of a southern African moth (Gunn and Codd 1981), apparently the Decorous Red Tiger moth (*Brephos decora* - Noctuidae) (Ball 1997).

It was T.S. Eliot (1919) who wrote 'the historical sense involves a perception not only of the pastness of the past, but of its presence' (Tripp 1983). Memory, the presence of the past, is a form of meeting and, looking back, present-day natural historians owe a huge debt of gratitude to those who have gone before.

The first descriptions of southern African butterflies were made by the Swedish naturalist Carolus Linnaeus (1707–1778) in the tenth edition of his book *Systema Naturae*, published in 1758. Shortly afterwards, in 1777, Pieter Cramer described a large lycaenid butterfly from the Cape of Good Hope, the Orange-banded Protea-scarlet (*Capys alphaeus alphaeus*). The larvae of these butterflies are found within the flower buds of *Protea* species. Cramer's description was in his four volume study on butterflies, *Papillons Exotiques,* the first volume of which appeared in 1775. The nymphaline *Catacroptera cloanthe cloanthe*, presently known as the 'Pirate', was described by C. Stoll in 1781, from 'the Cape of Good Hope.' This locality was used rather liberally, and many insects originating from what was then called Natal (now KwaZulu-Natal) to Namibia received this locality record. In 1791, Stoll published a supplementary volume to *Papillons Exotiques*, in which a number of South African butterflies were illustrated in colour. By 1800, 67 southern African butterflies had been described (Ball 1994).

Carl Thunberg (1743–1828) was known as the 'father of Cape botany', and was one of Linnaeus's favourite students. He spent 3 years (1772–1775) at the Cape, during which he amassed a herbarium of 23,510 specimens, as well as 25,000 insects, including numerous moths and butterflies (Gunn and Codd 1981). Thunberg succeeded Linnaeus as professor of Botany at Uppsala University, and was the first of a number of 'super-Swedes' [also Johan Wahlberg (1810–1856), killed by a wounded elephant at Lake Ngami, in what is now Botswana and Axel Erikkson

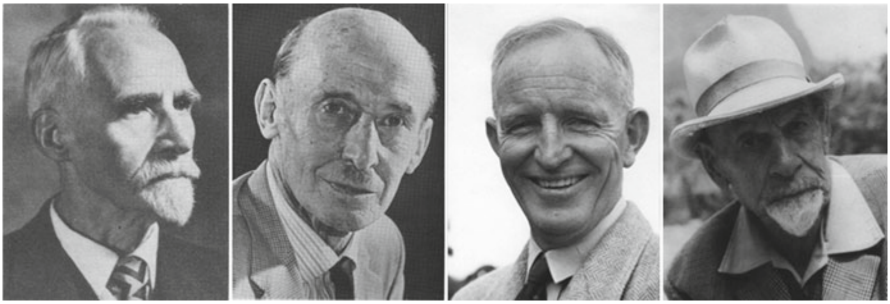

Fig. 12.2 Four leading S. African Lepidopterists: *left to right*, Anthonie Janse, Georges Van Son, Ken Pennington, Charles Dickson

(1846–1901)] who each made an enormous explorative contribution to lepidopterology in southern Africa.

The nineteenth century was the halcyon time of local lepidopterology. Amongst the educated middle class, who had time at their disposal, biophilia and the enthusiasm to marry leisure and travel with learning and the resources to accommodate such pursuits, lepidopterology became a popular hobby. Fifty-nine southern African butterflies were described between 1800 and 1849 and 364 between 1850 and 1899 (Ball 1994). The major contributers to this taxonomic expansion were Jacob Hübner, J. de Boisduval, J.C. Fabricius, Edward Doubleday, W.C. Hewitson, R. and C. von Felder, Hans Wallengren, A.G. Butler, Roland Trimen and Aurivillius. Roland Trimen (1840–1916) was undoubtably the leading contributor in this era. He was the Curator of the South African Museum in Cape Town from 1872 till 1895. He published a Catalogue of South African Butterflies (1862–1866). Trimen was assisted by James Bowker (1822–1900) in the well-known and significant three-volume South African Butterflies (1887–1889). In 1898, Aurivillius published his immense work *Rhopalocera Aethiopica*, which dealt with the entire Afrotropical region.

The early twentieth century saw the initiation of A. Seitz's monumental study, *The Macrolepidoptera of the World*. The 13th volume, written by Aurivillius, was published in 1925 and dealt with the butterflies of Africa. From 1900 to 1949, another 127 local butterfly species were named and from 1950 to 1999 a further 237 were added. Leading lepidopterologists who advanced local knowledge during this century were Harry Eltringham, Anthonie Janse (moths), H. Stempffer, W.H. Evans, D.P. Murray, Georges van Son, Dawid Swanepoel, Elliott Pinhey, Gowan Clark, Charles Dickson, W. Peters, Ken Pennington, C.B. Cottrell, N.D. Riley, G.E. Tite, V.G.L. van Someren, T.G. Howarth, P.R. Ackery, B. D'Abrera, A.H.B. Rydon, Clive Quickelberge, R.I. Vane-Wright, L. Vári, R. Carcasson, Douglas Kroon, J. Kielland, Graham Henning, Stephen Henning, Martin Krüger, Hermann Staude and Ernest Pringle (Ball 1994, 1997). Brief biographies of four of these local key twentieth century lepidopterists follow, accompanied by portraits (Fig. 12.2), to give a slight flavour to the weft and warp of the Aurelian history of this Afrotropical subregion.

Anthonie Janse (1877–1970) became the 'father' of studies into South African moths. Born in The Hague, Holland, he settled in South Africa in 1899. He was a teacher at a small farm-school in the Northern Transvaal (old name) for a few years. In 1923 he became the honorary professor of Systematic Entomology at the Transvaal University College (which later became Pretoria University). Janse wrote over 50 scientific articles as well as numerous books mainly of a taxonomic nature. His immense energy and sheer hard work became the bedrock of moth studies and sampled material in this subregion. His vast collection is housed in the Transvaal Museum (Northern Flagship Institution) in Pretoria. His *magnum opus* was *The Moths of South Africa*. This was published in seven parts between 1932 and 1964, with an eighth part in manuscript form at the time of his death. He influenced many others into the love of the subject, including Georges van Son and Gowan Clark (1888–1964). The latter became a most prolific illustrator of 260 magnificent local life history paintings of Lepidoptera (mainly butterflies) (Ball 1994).

Georges van Son (1898–1967) was born at the Castle Gorodistsche, Narishkino in the province of Orel in Russia. His mother was Countess Nathalie Kamarowsky and his father, Henri, was a French-born Dutch diplomat. His father was a keen amateur entomologist. Georges served time in the Imperial Russian Navy. Henri was killed by a Bolshevik sniper in July 1918. After the revolution, the family's estate "Doubròva" was left in ruins (Russel 2009). Georges, his mother and sister Eleonore were incarcerated. He was occasionally released to play the piano for a butcher's wife! The remaining van Son family later fled to Holland. Georges worked in Zoological and Entomological institutions in Holland and London before moving to Pretoria. This happened in 1923 when he was recruited by Dr. Janse to work as a personal assistant on his large private moth collection. In 1925 he was appointed as an entomologist at the Transvaal Museum, where he soon became curator. He studied extramurally to obtain B.Sc., M.Sc. and D.Sc. degrees through the University of Pretoria. Proficient in six languages, he was also a natural historian, botanist and horticulturalist (mainly orchids and succulents) of note. He wrote numerous entomological papers as well as four comprehensive volumes on *The Butterflies of Southern Africa* (1949, 1955, 1963 and 1979), the final volume of which was published posthumously. His name is honoured eponymonously in southern African butterflies (eight taxa), beetles, Diptera, a nemopterid, moths, a grasshopper, a spider, a solifugid, a gecko, a race of canary, a grass taxon and an amaryllid (Russel 2009).

Kenneth Misson Pennington (Ken or KMP) (1897–1974) was a Rhodes scholar at Oxford. He served in the Royal Flying Corps during World War I and received the Air Force Cross whilst a pilot in Mesopotamia. During this conflict, he was shot down by Turks and then was involved in a second crash within 20 min of being rescued by another pilot. He practiced as a solicitor and barrister for a few years before becoming a school-master at Michaelhouse, a secondary school in the KwaZulu-Natal midlands, for 35 years (Ball 1994). His father (who himself discovered two South African butterflies) encouraged his love of natural history when Ken started a collection in 1912. This became the most complete southern African butterfly collection (of its time) and is now housed in the Transvaal Museum. While on honeymoon, KMP decided to do some hill-topping one afternoon. Upon pulling himself over a rocky ledge, he found himself staring into the face of a leopard. Fortunately the leopard slunk off.

Ken published extensively and was a founder member of the Entomological Society of Southern Africa and later president of this society in 1965. KMP described 33 new taxa of butterfly and 13 others bear his name (Ball 1994).

Charles Dickson (1907–1991) started collecting butterflies in Cape Town when quite young. The works of Trimen were a very positive influence. Gowan Clark and Charlie formed a formidable pair in advancing local knowledge of many life-histories, particularly of Cape butterflies. He was small in stature, but big in heart. He became the foremost authority on the butterflies of the Western and Northern Cape Provinces. He was the author of numerous descriptions of new butterfly taxa, most of them in the *Entomologist's Record and Journal of Variation*. He was also the author of many books, a lover of old marques of motor cars, a fine artist, a most prolific writer of letters and a most generous friend.

12.4 South African Red Data Books and Red Lists

At the time of the first South African Red Data Book – butterflies (Henning and Henning 1989), 632 species of butterfly had been described from within the borders of South Africa. According to the limitations of the then extant IUCN criteria, 102 of these taxa were thought to be exposed to some level of threat. Ninety-one taxa were categorized as Rare. A number of the latter had a marginal distribution in South Africa, and 80% of these were lycaenids. This Rare category has subsequently been disbanded, as 'rare' taxa are problematic in categorising and are not necessarily at risk or threatened. Two species were listed as extinct and 39 taxa were treated as Indeterminate due to the paucity of data relating to them. There were thus 141 taxa included in this RDB. This study was later updated and revised (Henning and Henning 1992, 1995). A more objective set of Red List criteria was published in 1994 (IUCN 1994). An improved and more detailed and quantifiable set of criteria appeared in 2001 [for use at a global level (IUCN 2001) – and updated on the Red List website] and 2003 [for use at a regional level (IUCN 2003)].

The second (revised) South African Red Data Book: butterflies was published by Henning et al. (2009), includes a refined Red List (RL). This highlighted 63 taxa [3 extinct (all lycaenids) and 60 extant, the latter designated as: 12 Critically Endangered (9 lycaenids), 16 Endangered (14 lycaenids) and 32 Vulnerable (25 lycaenids)]. In relation to the extant threatened taxa, the Biome Units (BU) in which these RL taxa occur are – Grassland 28/60 (46.7%), Fynbos 19/60 (31.7%), Savanna 6/60 (10%), Albany Thicket 3/60, Indian Ocean Coastal Belt 2/60, Succulent Karoo 1/60, Nama-Karoo 1/60 and Forest 1/60. Nearly 80% of these taxa occur only in two BUs (Grassland and Fynbos). Most of the extant 48 threatened lycaenid taxa are myrmecophilous habitat specialists (83%). Eleven of the 63 RL taxa are/were found within 100 km of Cape Town, where there has been about 350 years of habitat modification

(Ball 2006). All the presumed extant 2009 RDB are globally threatened. Sadly, the obligate myrmecophilous South African lycaenid (thecline) taxon *Erikssonia edgei* Gardiner and Terblanche 2010 (previously confused with *E. acraeina* Trimen, 1891), was described after its probable extinction.

12.5 South African Lepidoptera Conservation

Unfortunately, rather little effective butterfly conservation emanated from the 1989 RDB. Of the nine Endangered and Vulnerable taxa listed, eight have subsequently declined and only the southern Cape thecline lycaenid *Chrysoritis cottrellii* has had a stable population trend (reflecting discovery of a few more isolated, montane localities). Four of these taxa appear to be '*de facto* extinct.' Sadly, despite the fact that although the lycaenid *Trimenia malagrida malagrida* was in a Nature Reserve (now a National Park) in Cape Town, this did not prevent its declining population trend and probable 'extinction' in the 20 years since the first RDB was published. This appears to have been due to a lack of effective habitat management [in particular the increased fire load from invasive alien vegetation in the Kloof Neck region and a synergistic combination of factors including too frequent fires at the time of the dry late summer emergence of the univoltine adults (Ball 2006)]. This was coupled with the probable synergism of climate change (Midgley et al. 2002, 2003; Rutherford et al. 1999, 2000).

Urgent conservation management should be applied in relation to the 60 RDB 2009 'at risk' taxa, with the 12 Critically Endangered taxa receiving the bulk of this attention. Sadly at least 2 of these 13 taxa appear to be actually 'extinct.' Conversely, the absence of fires/active fire suppression for a number of years in the locality of the lycaenid *Erikssonia edgei* in the Limpopo Province, appears to have led to its local extinction (Dobson and Garvie 2005).

The major cause of the threat(s) to the RL butterfly species of South Africa is habitat loss. A variety of deleterious stochastic factors has been involved in the advent of the status of the 60 'at risk' taxa. In decreasing order, the following categories of threat(s) have been identified for these taxa (Ball 2006): altered fire regimes (either increased or decreased – with the effects greatest on taxa with mymecophilous larvae) 48%; alien invasive vegetation (40%), urbanisation (25%), agricultural activities (22%) and plantation forestry (17%). These risk factors are synergistically compounded.

The Lepidopterists' Society of South Africa has been instrumental in getting four reserves established. These are each dedicated to the conservation of a single lycaenid taxon: the Roodepoort Copper *Aloeides dentatis dentatis*, the Brenton Blue *Orachrysops niobe* , the Coega Copper *Aloeides clarki* and the Heidelberg Copper *Chrysoritis aureus*. The long term success of establishing small reserves, without connectivity and enshrouded by urban development, for the final small remnant populations of such habitat specialist myrmecophilous lycaenids, remains to be seen.

The extant Biodiversity Act (2004) of the Republic of South Africa makes provision for the setting aside of special ecosystems for conservation. However this is most difficult to implement as only about 5.6% of South Africa's land surface is conserved (Jackleman et al. 2007). These comprise 479 Type 1 (National Parks, Provincial and Local Authority Nature Reserves and Forest Nature Reserves) and 471 Type 2 (Mountain Catchment Areas, Wildlife Management Areas, private nature reserves, National Heritage Sites, Forest Areas, bird sanctuaries and botanical gardens) protected areas (Department of Environmental Affairs 2007). The objective in the National Biodiversity Framework (DEAT 1998) is to increase the protected area network to 8.5% of the land surface area of South Africa by 2012. Sixty percent of the 'at risk' butterfly taxa are not found in reserves (Ball 2006).

The observation by New (2010), 'the major impediments to furthering conservation interest include lack of effective communication and of logistic support from within the area of interest' is also perfectly valid in South Africa. More effective communication is sorely needed between all the role players. The SMART objectives in insect conservation plans are also most apposite (New 2009). This ensures accountability and practical values so that the defined actions are Specific (unambiguous), Measurable (specified criteria and objectives), Appropriate (related to the overarching planned goal as set out in the initial mission statement or broad objective), Realistic (attainable within the confines of the specified resource and time constraints) and Time-based (specified completion time) (New 2010).

12.6 Current Research

12.6.1 Lepidopterists' Society of Africa (LepSoc)

The bulk of the records, specimens, publications and research into southern African Lepidoptera over the last 50 years have come from a small, ageing and dwindling, but passionate group of mainly amateurs. An example of this issue is exemplified in the recent taxonomic paper by Martin Krüger (2009) on 26 new nacophorine geometrid moths in the Afrotropical region. Twenty of these 26 taxa were discovered by amateurs (=76.9%). LepSoc had its genesis in 1983 as the Lepidopterists' Society of Southern Africa. In 1996 it transformed to the Lepidopterists' Society of Africa. It presently has about 200 members with about 175 in South Africa (Edge 2010, personal communication). The aims of LepSoc are: (1) the scientific study of the Afrotropical Lepidoptera, (2) the publication of original scientific and popular material, (3) the conservation of Lepidoptera and (4) the equipping of infrastructure that facilitates interactions between its members as well as wider society. Significant achievements during the last quarter of a century have been the establishment of four gazetted South African 'butterfly' reserves, the quarterly journal *Metamorphosis*, a number of books and publications, many conferences, workshops and presentations. These are all aimed at the acquisition and spread of lepidopteran knowledge, including taxonomy, distribution, survey data, ecology – including enhanced knowledge of life-histories, range shrinkage and expansion, threats, habitat management and the conservation of our endangered taxa. This knowledge is translated into action through relationships with key role players in conservation and Natural Science. An outstanding development has been the superb Lepidops computerized relational database (developed by Bennie Coetzer). Apart from its data – acquisitional and processing ability, this now also has about 32,000 digital images (Staude 2010, personal communication) of Afrotropical Lepidoptera (including metamorphotic stages).

LepSoc has inaugurated a custodianship programme to monitor and increase research of the 13 Critically Endangered butterfly taxa. This will be coordinated by the local experts on these taxa. It is anticipated that this programme will later include all Endangered, Vulnerable, Near Threatened and Data Deficient taxa as constrained resources allow. This process is vital in assessing the dynamic changes that can particularly affect our narrow range endemics.

Globally, amongst the more enlightened conservation agencies, there is a growing appreciation and understanding, of the vital role amateur entomologists play in gathering vital knowledge, including distributional data (Johnson 1999; Asher et al. 2001; Sands and New 2002; Remington 2003; Ehrlich 2003; Boggs et al. 2003; McGeoch 2002; Parmesan 2003; Watt and Boggs 2003; Gates 2003). As Wilson (2003) succinctly asked, 'Could astrophysics exist without a map of the stars?'

12.6.2 The Southern African Butterfly Conservation Assessment (SABCA)

This excellent study, commenced in 2007 and with sampling completed in March 2011, has been a highly successful collaborative joint project between the Animal Demography Unit (ADU, University of Cape Town, who supplied the energetic Silvia Mecenero as co-ordinator), the Lepidopterists' Society of Africa (LepSoc) and the South African National Biodiversity Institute (SANBI). Publication of this work is expected in late 2012. Considerable cooperation was also obtained from local and international museums, conservation (and permitting) agencies, forestry departments and private land owners. This project was co-funded by SANBI and the Norwegian Ministry for the Environment. LepSoc (and many self-financed members) made a significant contribution towards the funding of field surveys. The South African Biodiversity Information Facility (SABIF) furnished a grant that was used towards the funding of data technicians, who captured considerable information from many collections. The aims of the 4 year project were to:

1. Gather and digitally integrate all known distribution records into a comprehensive relational database.
2. Co-ordinate gap analysis utilising the known data to identify priority areas and taxa for focussed field surveys.
3. Survey the butterflies of the atlassing region in relation to additional localities (due to data deficiency) particularly of threatened taxa and their known habitats.

4. Increase public awareness of both butterflies and their conservation through regular project feedback and ongoing digital image submission.
5. Map the known distributions of all the butterfly taxa of the atlassing study area.
6. Atlas the distributions of all butterfly taxa in relation to a specific resource-based habitat view.
7. Assess the conservation status of each taxon according to the IUCN criteria.
8. Assess major known threats of all taxa.
9. Increase capacity in accurate butterfly identification leading to additional ecological information and further databasing within and between institutions. The most important of the latter are the conservation agencies and land owners.
10. Create and deliver an authoritative, updated butterfly Conservation Assessment for all taxa to integrate with conservation development, planning and execution.

This study of the most accurate distributional information available has yielded data sets that will hopefully lead to (a) more effective conservation assessment, (b) the increased community appreciation of butterflies as ambassadors of biodiversity, (c) better planning and ultimately invertebrate conservation management in South Africa, Lesotho and Swaziland. An excellent locally developed LepSoc software relational database program (Lepidops) was and is being used for data capture. The fieldwork directed by a rigorous expert-based gap analysis was mainly performed by the approximately 175 local LepSoc members (Mecenero 2011, personal communication). An expanding Virtual Museum was added to the website. This has encouraged the raising of lepidopteran awareness of the public. The SABCA initiative elicited approximately 17,100 photographic submissions to SABCA's Virtual Museum (VM). This in itself has been an outstanding success with 300–500 monthly imaging submissions towards the end of the project. Considerable additional locality records have been derived from these citizen scientists. This enthusiasm needs to be harnessed and continued. The data will lead to an updated Red List and will help to better determine butterfly hotspots and their related habitats. The task is huge. A salient comparison can be made with the outstanding Millennium Atlas of Butterflies in Britain and Ireland (with combined area of 314,328 km², 59 historical resident species and three regular migrants and 200 years of data). This study had about 10,000 recorders to give substance to its findings (Asher et al. 2001). In contrast, the SABCA project had less than 200 recorders (2% of the UK total) for an area approximately four times as large and with about tenfold more species.

12.7 Legislation – Help or Hindrance?

The extent to which legislated protection actually conserves a taxon or habitat crucially hinges on the presence of two factors. These are the social and political will to make a recovery programme work and to the extent to which the threatening factors are addressed (Kitching 1999).

Mere legal protection of insect taxa is usually ineffective, and may in fact be counter–productive (Brooks 2002). An example of poorly considered legislation in relation to Lepidoptera conservation in South Africa was the Amendment of Schedule 2, Ordinance 19 of 1974 in the (then) Cape Province. This became effective on 13 February 1976. This legislation was bereft of any associated practical measures of habitat management or protection. In spite of the objection raised by Whitehead and Geertsema (Geertsema 2005, personal communication), the then Cape Province continued with the listing. Sixteen butterflies were included in this legislation. Two of these taxa appear to have become extinct in the intervening years because of habitat destruction/modification. Only five of the remaining taxa face some threat. Half of the 'legally protected' taxa (eight species) have no currently perceived level of threat. No practical conservation management nor significant scientific monitoring of data on these taxa has until the present been sought or considered in the intervening years since 'promulgation' (Ball 2006).

Legislative efforts to protect individual threatened insect taxa, from the collection of individual specimens, are usually pointless, unless there is concomitant protection of their habitats from degradation or destruction (Brooks 2002). In 2003, Staude and Ball met on behalf of the Lepidopterists' Society of Africa with CapeNature for a series of successful talks which resulted in an enlightened and user-friendly situation in the Western Cape Province. All legislation on biodiversity becomes meaningless if we do not know what our biodiversity is (= basic taxonomy) and the relationship of species to habitats. Particularly in relation to invertebrate biodiversity science and conservation, there has been a lengthy period of poor legislation, uncertainty and lack of a co-ordinated national approach to the management of the environment in South Africa. However, Act 10 of 2004, the National Environmental Management: Biodiversity Act (NEMBA) was signed into law on 31 May 2004 and came into effect on 1 September 2004. It is a mandate of SANBI to regularly (at least every 5 years) update the Minister on the state of South Africa's biodiversity. In relation to butterflies, this in itself will require much post-SABCA monitoring. Another local new Act is the Protected Areas Bill (PAB), which was part of the Biodiversity Bill until September 2002.

Scientific research is the foundation of good conservation. Legislation relating to invertebrate biodiversity should be appropriate, reasonable, based on good data, flexible, enforceable and should stifle neither research nor interest.

12.8 The Bureaucratic Impediment

The importance of adding to the taxonomic, ecological and distributional data on our South African insects cannot be overemphasised. To date, amateur naturalists have provided most (>80%) of the relevant material/observations on our South African butterflies and moths, as well as for many other insect groups. They should be encouraged to continue providing such needed data. Future invertebrate conservation management decisions will need an ever increasing and ongoing supply of ecological data and enthusiastic citizen scientists. It is obvious that with the impending ecologically lethal cocktail of habitat fragmentation, loss of habitat connectivity/corridors and accelerating climate change, greater interaction between all parties must be encouraged. Mutual respect and cooperation between the suppliers and users of such information is vital. This is precisely the gist of Southwood's foreword in 'Ecology of Insects: Concepts and Applications' (Speight et al. 1999), "Not surprisingly, the text emphasises the truth that 'it all starts with good observations in the field'." In order for entomologists to make these 'good observations on the ground' scientific sampling is needed. Both ecosystem management and directed conservation need specific information on local species composition as community assemblages vary in habitat characteristics and reveal different responses to extinction thresholds (Lin and Liu 2006). Taxonomy (particularly of insects) requires scientific sampling. Robert May (1990) said 'without taxonomy … the house of biological science is a meaningless jumble.'

Much of the baseline South African lepidopteran discovery, taxonomic data, survey information, ongoing monitoring and unravelling of ecologies has been and is being performed by a small, decreasing group of amateurs. This worldwide phenomenon has been rightly termed the 'extinction of experience' (Pyle 1993; Louv 2005; Cheesman and Key 2007). Miller (2005) spotlights this under-acknowledged aspect of the biodiversity crisis, as increasing urbanisation contributes to the culling of the understanding, contact and monitoring of our environment.

In South Africa, the acquisition of invertebrate samples may require both collecting permits as well as interprovincial export/import permits. Some provinces do not have any such legal requirements. Each of South Africa's nine Provinces has different regulations and regulatory bodies. There are also National Parks (SANParks) and Provincial Conservation authorities with differing conditions/requirements. The ease of getting a plethora of these permits varies between very easy and imposwsibly complex/no response. The appropriate time needed to gain such paper documentation varies between a few months to (in some cases) no response 8 years after sending the correctly completed forms by registered mail. Some of the sampling permits are only valid for 3 months (while the separately issued interprovincial 'import - export permits' often come after the sampling permit has expired). Some of the authorities also require 2 weeks advance notice of an intended sampling visit, which is very difficult if one is not clairvoyant as to future weather conditions. This is particularly problematic for certain of our insect groups in xeric regions, where some adults only emerge very briefly immediately after 20–25 mm of rain in mid-summer.

It is a great pity that in 2010, resource-constrained bureaucrats have been and are often the rate limiting step as to whether certain local scientific research takes place or not. This sentiment was recently echoed by Marian Shinn (MP – Shadow Minister of Science and Technology) who wrote, 'International scientists I have spoken to are aghast that South African bureaucrats have the final say on scientific matters'

(Shinn 2010). This is a refrain found in many Sub-Saharan countries where there also often appears to be a lack of political will by most governments to implement their biodiversity commitments (Scholtz and Mansell 2009). In some local South African Provinces, all vertebrates and invertebrates (apart from the blind spot of 'legal' ultraviolet-insect killing devices) are 'treated' equally before law, without any concept or appreciation of *r*- and *K*- selection (Pianka 1970). Even the scientific sampling of insect material for taxonomic and phylogeographic purposes at a doctoral and post-doctoral level (and financed by state grants) has been/is being actively or passively prevented, hindered or impoverished by the bureaucratic yoke of permitting authorities of certain provinces/conservation bodies. At present, it is also perfectly legal to surround a farm, game reserve or guest lodge with numerous ultraviolet-insect killing devices, which indiscriminately carbonise vast numbers of insects every night of the year. A personal observation of a number of such devices at a rural location on 1 October 2004 (spring), between 20h30 and 21h00, in the Clanwilliam district of the Western Cape Province, revealed on average one insect being carbonized every 15 s (Diptera>Lepidoptera>Neuroptera>Hymenoptera). This included one partially burnt specimen of the chrysopid lacewing *Turnerochrysa mirifica* Kimmins 1935, which was at the time only known from three specimens ever sampled in South Africa and Namibia. However, the removal of one undescribed, precarbonised individual from the frame of one of these indiscriminate killing machines, for taxonomic purposes, without a permit, to better define our biodiversity, constitutes a criminal offence. It is ironic that to sample one insect from this site requires both a permit as well as a follow up 'obituary notice' to the permitting authorities, whilst the act of legally incendiarising other insects by a factor of millions does not. For too long, the bureaucratic tail has wagged the dog of local scientific (including in particular, entomological) research. It must be stressed however, that some of the permitting authorities are extremely efficient and helpful in the assistance of entomological research. This has been particularly noticeable for butterfly research during the SABCA project and it is hoped that this will continue.

The catachretic shift in the concept of conservation from that of management based on scientific, data-rich, ecological decision-making to one of the data-free issuance of the 'hunting permit of paper conservation,' is of concern. It is interesting to note what Sir David Attenborough recently said at the launch of a new organisation, the Society of Biology in the United Kingdom. 'Children are being denied the chance to learn one of the key 'foundation stones' of science because of laws that prevent them from collecting wild flowers, insects and fossils' (Gray 2010). He went on to say that '…. laws protecting species from being targeted by collectors have also led to a decline in children being able to collect other non-protected species.' He added that 'allowing children to collect insects, animals and other objects they found around them helped them to learn the skills needed for taxonomy, the science of classifying species. Taxonomy is the foundation stone of the biological sciences. The pendulum has swung too far against collecting.'

12.9 Future Directions

As with most countries of the world, we need an increasing recruitment of younger entomologists, particularly those who were previously disadvantaged. We need a milieu in which biophilia and curiosity about our biodiversity can be nurtured. 'The environment encountered during childhood becomes the baseline against which environmental degradation is measured later in life' (Miller 2005). Impediments to meaningful sampling should be reconsidered by people who have actual knowledge of entomology.

There is a need to better utilise the skills and knowledge of our lepidopterists. Bureaucracy needs to appreciate the huge costs amateurs incur in self-funding insect research. Many of those involved have bequeathed their collections to Provincial/National Museums.

Relational data bases need to be established, updated, expanded and distributed.

Greater dissemination of information is needed to the public, farmers, local, provincial and national authorities. In view of the fact that so many threatened butterfly taxa are not found in protected areas there is a particular need for Spatial Biodiversity Planning in prioritising areas of biodiversity conservation through a systematic, objective and scientifically robust process (Margules and Pressey 2000).

The promotion of habitat quality, continuity, heterogeneity and connectedness in insect conservation will only take place through thorough and appropriate knowledge, translated into good management via effective communication (Stewart and New 2007).

More cogent, appropriate and meaningful legislation is needed in the sampling, study and research of entomology. Thankfully, many more Provincial and National Conservational bodies are showing an increasing degree of understanding, appreciation and assistance in this quest. The SABCA initiative has been most useful in this regard. It has facilitated an understanding of what can be accomplished through genuine collaboration. The South African National Biodiversity Institute should be taking the lead in this regard for all insect orders.

12.10 Conclusions

The South African lepidopteran component of the Afrotropical region is significant, considering its austral location. In some respects, the butterfly component of South Africa is relatively well known from an inventory aspect. Sixty of the 796 described South African taxa face varying levels of real threat. All possible means within the constraints of the system should be utilised to safeguard these and other taxa. A vastly larger effort is needed to comprehensively assess and atlas the moths of the same region. Apropos all our invertebrates, we need however to add to our focus an understanding of habitats based on resources and conditions required by insects and their access to them. This is a significant shift from simplistic and ineffectual notions of insect habitats as merely vegetation units or biotopes (Dennis 2010).

The paucity of scientific sampling of the insects of this vast subregion by relatively few researchers means that new discoveries of insects are being made each year (Scholtz and Chown 1995). We are a long way from knowing all the components of our lepidopterous fauna – particularly the moths, let alone their distributions and ecologies. Conservation takes place through appropriate action and management where species and habitats occur. Without knowing where species and habitats are, conservation is almost impossible. For this reason distributional records are the foundation for almost all our efforts to conserve species (Fox et al. 2006). Effective conservation depends on an ongoing knowledge of the biota being conserved.

Underpinning any conservation process should be a strong philosophical and ethical foundation (Gorke 2003; Samways 2005) that gives our labour both purpose and relevance. Our mission is not only the conservation of species (and their habitats), but also of the various infraspecific polymorphisms, subspecies and evolutionary significant units (ESUs) as well. Important questions remain; for example, should we be conserving the topotypes (and thus their molecular signatures) of various fairly widespread taxa, where the type localities serendipitously, happen to reside near to or in expanding cities and towns? At the core of our conservation attempts is the primacy of understanding the ecological processes relevant to our local conditions. The understanding of these processes in a specific habitat necessitates a plethora of distributional, phenological, taxonomic and synecological study. A salient issue for the South African Lepidoptera, and noted earlier in this essay, is that the bulk of the research into this order is being done by a small, aging band of self-funded amateurs and fewer alpha taxonomists, with very little recruitment occurring.

Building on the sterling work of these predominantly amateur studies, the excellent ongoing relational computerised Lepidops programme of the Lepidopterists' Society of Africa and the South African Butterfly Conservation Assessment will add considerable accessible data. Incrementally increasing sampling, monitoring and study is needed at a time of extinction of experience, expertise and knowledge. There is still a large bureaucratic impediment in a number of South African areas to validate and legitimise entomological research. Although there has been a considerable degree of healthy cooperation regarding sampling permits from many bureaucratic agencies, for many insect groups there is still an often hostile or apathetic response from some officials (Scholtz and Mansell 2009). Some forget that the nursery of insect taxonomy is often the juvenile inception of collecting. This interest, often starting with butterflies, often progresses to other insect, animal and plant expertise and in a maturation to research.

A son of Africa, the Senegalese poet, Baba Dioum wrote 'In the end, we conserve only what we love. We will love only what we understand. We will understand only what we are taught' (in: Rodes and Odell 1992). Hopefully the world we have borrowed from our children will continue to be adorned, enriched and sustained by the present, magnificent cornucopia of life.

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Part IV
Regional Themes and Developments

Chapter 13
Insect Conservation Developments in Central Europe

Karel Spitzer

13.1 Introduction

Central Europe is situated at the biogeographical crossroads between temperate West and East, between North and South. The character of insect fauna is derived from a long ecological-historical succession which has taken place during Holocene period – at least since the end of the last Pleistocene Ice Age (about 12,000 years B.P.). The Holocene ecological succession started from forest-tundra biomes to various forest types dependent on elevation, diverse geomorphology and postglacial migrations of biota (Firbas 1949; De Lattin 1957; Jeník and Price 1994; Schmitt 2009). During the relatively warmer Holocene postglacial periods only the open mountain ridges, montane glacial cirques and open waterlogged peatbogs and fens preserved non-forest "relict" arctic/subarctic/boreal and alpine insect populations in habitats other than closed forests. Local and scattered dry grassland biomes on rocky limestone or volcanic substrates provided refugia for penetrating xerothermic southeastern and Mediterranean insect species (De Lattin 1957; Malicky et al. 1983) Both types of azonal locally distributed habitats represent very important paleorefugia (sensu Nekola 1999) for nature conservation projects, with values extending well beyond those for entomology alone. The paleorefugial habitats (biotopes) of dominant forested landscape are preserved in virgin forest conditions also in limited numbers of local places of recent central Europe: natural montane mixed forests, lowland deciduous /oak/ woods and several types of wetland forests. Human-induced impacts on the original postglacial biomes resulted in far-reaching alterations and fragmentation of most types of original ecosystems. For the original primary distribution of natural biomes and reconstruction of vegetation, several mapping projects for some central European countries are available (for example, Neuhäuslová 2001, with plant ecological bibliography) and provide habitat characteristics and basic

K. Spitzer (✉)
Biology Centre CAS, Institute of Entomology,
Branisovska 31, CZ 37005 Ceske Budejovice, Czech Republic
e-mail: spitzer@entu.cas.cz

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introductions for investigations of insect communities. Most data are valid across the boundaries of the states and political units, and help to emphasise that the political frontiers of central Europe are not important for local biogeography, insect conservation policy and division of this chapter. The main points that follow apply across the region.

13.2 Outlines of Insect Conservation History in Central Europe

Research on the central European insect fauna has rendered it one of the world's best examples of relatively complete inventory of most taxonomic groups, with investigations starting from the early nineteenth century. Sound taxonomic knowledge, and ability to recognize very high proportions of the insects present, has enabled sound documentation in which to base assessment of changes and conservation needs at a level comparable with similar situations in most countries of northwestern Europe (Pax 1921; Bergmann 1951–1955; Malicky et al. 1983 with bibliography, Aspöck 2009). In most central European countries, production of comprehensive and annotated entomo-faunal check-lists, catalogues and insect community studies – both older and more recent – seems to be a tradition of local entomology and entomofaunistics. Such tradition provided excellent foundation for long term monitoring, and research on insect communities and on population fluctuations of many of the more remarkable and charismatic taxa that are now of conservation interest. Such traditional studies are again occurring in most parts of central Europe and in some cases implemented in recent insect conservation projects (as examples, by Ebert and Schmid 1981; Spitzer and Danks 2006; Hacker and Müller 2006).

Recent insect community research is also usually based on good traditional plant ecological investigations of specific central European ecosystems and knowledge of taxonomic endemicity of local biota, together with associated data on environmental anthropogenic impacts (e.g. Pax 1921; Novák and Spitzer 1982; Rabitsch and Essl 2009). This background is essential for identification of recent threats for insect communities and evaluation of fragility of endangered populations. Habitat (biotope) conservation has become the most important management theme for protection of rare and endangered taxa. Several older publications that emphasise aspects of conservation entomology values of habitats (e.g. wetlands) and focused on individual species (such as the popular Apollo butterfly, *Parnassius apollo*) were published early in the twentieth century (e.g. Pax 1916, 1921).

During the last century a number of studies dealt with structure and change in insect communities in the region. Comprehensive ecological surveys of communities of central European freshwater insects, with their values evident in species bioindicator evaluation, conservation and protection of water quality, seem to be typical for this recent period (see reviews with bibliographies: Moog 1995; Soldán et al. 1996, 1998; Wildermuth et al. 2005). The conservation research of terrestrial entomofauna is based on the central European tradition of taxonomy, faunistics, community ecology (cf. e.g. Hausmann 2001) and observations of population fluctuations of some rare insects of natural communities within the well-designed network of reserves and other types of conservation areas (Novák and Spitzer 1982: the first concise textbook of Central European insect conservation; Škapec 1992: an illustrated comprehensive invertebrate 'Red Book' compiled by 22 local experts). Some examples of insect conservation of the most characteristic man-made grasslands and details of their traditional versus modern management in Austria and Germany are given by Ebert and Schmid (1981) and later by Pils (1994) in a very comprehensive monograph on these grasslands.

After 1980 a number of various types of Red Lists and/or Red Books of endangered insects were published (very often with particular attention to butterflies) in all countries of the region – see, for examples, Blab and Kudrna (1982) (Germany), Dabrowski and Krzywicki (1982) (Poland), Gepp (1983) (Austria), Wells et al. (1983) (Europe – world), the monumental Swiss volumes of the Lepidopterologen-Arbeitsgruppe (1987, 1997); Škapec (1992) (Czechia and Slovakia), Van Swaay and Warren (1999) (Europe), Farkač et al. (2005) (Czechia). Most of these publications summarise the situation in all the territory of central Europe and many of selected endangered species nominated for priority attention occur in all these countries. Data on conservation status from the cited publications have been partially endorsed formally in various types of national legislation and government lists of central European countries, as an important incentive for habitat conservation. In some of the publications, ecology of red-listed or bioindicator flagship or umbrella insects is integrated with plant ecological characteristics of central European habitats such as alpine forest-tundra, natural forests, wetlands and peatbogs (Wells et al. 1983; Hacker and Müller 2006; Spitzer and Danks 2006; Spitzer and Jaroš 2008; Rabitsch and Essl 2009) after long term monitoring of populations and evaluation of human impacts. Central European endemic insect taxa are a very special subject for habitat conservation and selected as flagships for isolated mountain units (e.g. Rabitsch and Essl 2009), highly specific biotopes such as halomorphic/halophytic (saline) grasslands (Kasy 1981) and boreal relict peatbogs (Spitzer and Danks 2006 with bibliography). Many of central European national parks are internationally situated in the trans-frontier regions and the park authorities publish joint international scientific periodicals that frequently include papers dealing with topics of conservation entomology (for example, the journal *Silva Gabreta* for the Bohemian/Bavarian Forest Mts. regions in Czechia, Germany and Austria and journal *Opera Corcontica* for the Krkonoše/Karkonosze National Park in the high mountains between Czechia and Poland). The mostly xerothermic lowland National Park Podyjí (Czechia-Austria) is subject of a unique monographic treatment of all the Diptera families of the park (collectively with 3,606 species) and habitat conservation of relict species (Barták and Kubík 2005 edited this comprehensive book with co-authorship of 38 European dipterists). The bioindicator value of Diptera species is very high and many rare taxa are represented. Their communities need further research and complex habitat conservation to follow from this impressive synthesis. Developments of central European insect conservation are not hampered by parataxonomy, imprecise applications of the morphospecies concept and false useless calculations of diversity.

'Biodiversity information' based on taxonomy and biogeography seems to be largely definitive, as exemplified by the above-mentioned local Diptera study. The rare advantages of excellent taxonomic foundation and relatively comprehensive faunal appraisals based on long-term collections of most insect groups allows us to be reasonably confident in the species conservation inferences we can draw.

13.3 Recent Priorities and Developments: Theory and Implementations

Theoretical aspects of central European insect conservation are associated with the applications of ecological (bionomic) strategies (r-K continuum: Southwood 1977; Rejmánek and Spitzer 1982; Spitzer and Lepš 1992; Hausmann 2001), models of paleorefugial/neorefugial habitats (Nekola 1999) and historical data on local habitats and their biota, in many instances with records of changes. With respect to paleorefugia, the most important insect communities with K-strategic relict taxa, local geographical races and West-Palearctic endemics, are components of fragments of virgin/natural forests (Gilg 2004; Hacker and Müller 2006), some wetlands (such as very isolated boreal peatbogs – Spitzer and Danks 2006), pristine alpine – subalpine biotopes (several chapters in Rabitsch and Essl 2009) and some types of relict dry grasslands (Kasy 1981; Barták and Kubík 2005). The isolated and relict insect populations of paleorefugia are the most important conservation subjects – examples are tyrphobionts of peatbogs (Fig. 13.1) including very local subspecies of Rosy Marsh Moth (*Coenophila subrosea*, Fig. 13.2) or subspecies of the boreal carabid beetle *Carabus menetriesi*, both species characteristic of bogs of the Bohemian Forest Mts – Šumava Mts (Bezděk et al. 2006; Spitzer and Danks 2006). The relict boreal insects of the Šumava Mts (Fig. 13.3) represent one of the most important conservation phenomena for establishment of a system of peatland nature reserves (core zone) of the local national park and trans-boundary UNESCO Biosphere Reserve between Germany (Bavaria) and Czechia (cf. Wells et al. 1983; Bezděk et al. 2006, with bibliography). A very unusual Pannonian relict moth of the halophytic (halomorphic, saline) grassland category is the geometrid moth *Chondrosoma fiduciaria*, recorded from only a few localities in Austria and Hungary (along the frontier zone between these countries); its occurrence in the Ukraine is not clear (Kasy 1981). For further examples of paleorefugial endangered insects and endemics see synecological Red Books with communities (e.g. Wells et al. 1983; Škapec 1992; Rabitsch and Essl 2009). Some of the more important such species are listed in Table 13.1.

Transitory habitats between classical paleorefugial systems (Nekola 1999) and appearence of neorefugial biotopes are managed old growth forests sometimes with cores of very old primary virgin forests (cf. Firbas 1949 and Gilg 2004). Such ancient natural forest habitats provide environments for survival of saproxylic insects associated with dead wood (e.g. diverse unique Coleoptera and Diptera, but even Lepidoptera – Tineidae: *Scardia boleti* and other related "Giant Tineid" moth species). Examples of "flagship" and "umbrella" taxa are included in Table 13.1.

Fig. 13.1 The Austrian WWF Reserve Purgschachen Moor (Styria) is one of the best examples of highly isolated peat bogs in Central Europe, and the unique habitat of many tyrphobiont and tyrphophile insects

Fig. 13.2 Larva of the Rosy Marsh moth (*Coenophila subrosea* Stephens), representing an endemic Central European geographical race from the internationally famous reserve Mrtvy Luh Bog, now part of the core zone of the Sumava National Park, Czechia

A comprehensive lepidopterological survey of natural and managed forests, with a list of species, conservation notes and recommendations for habitat protection in Germany (Bavaria) was compiled by Hacker and Müller (2006). Most of the natural old central European forest reserves belong to this transitory refugial category,

Fig. 13.3 The Sumava National Park is the only known locality of a subarctic pyralid moth *Pediasia truncatella* Zetterstedt outside the northern (boreal) parts of Europe

historically connected to the original pristine forests, where no special conservation management is generally needed.

Last but not least, even the cultural neorefugial biotopes colonized mainly by opportunistic widely distributed r-strategic insects, represent important localities for insect conservation, because the survival of many species has been determined in central Europe by traditional human impacts and management history of forestry and agriculture. Very popular butterfly species, such as the genus *Maculinea* (Large Blues) and many other taxa of Lycaenidae are charismatic insects of traditional meadows and pastures. In the Bohemian/Bavarian Forest Mts. and in some other localities, even the paleorefugial Bog Fritillary (*Proclossiana eunomia*) "invaded" old man-made meadows near montane peatbogs (e.g. Novák and Havel 2006; Schtickzelle et al. 2006). Another very charismatic papilionid butterfly – the Southern Festoon (*Zerynthia polyxena*) is associated only with weedy food plants of the genus *Aristolochia* – probably both species, locally common, were introduced to southern central Europe by ancient agriculture and vineyard management. Recently Southern Festoon populations were introduced to many new localities by butterfly enthusiasts (Baumann 1981). Maintenance of traditional agricultural regimes and practices, and avoidance of undue intensification, is a major need for insect conservation throughout the region.

In temperate Europe butterflies are associated mostly with neorefugial traditional agriculture landscape – the subject of hundreds of recent publications (for representative general bibliography see Bergmann 1951–1955; Wells et al. 1983; Pils 1994; New 1997; Settele 1998, 2009). The model examples (possible umbrella species) seem to be the *Maculinea* species, namely the Large Blue (*Maculinea arion*) and its close relatives and many Satyrs (Satyrinae), with most attention to their conservation

Table 13.1 Examples of refugial threatened insects in central Europe

Species	Paleorefugium	←Transitory habitat→	"Man made" neorefugium
Chondrosoma fiduciaria (Geometridae, Lep.)	Halomorphic, saline semiarid grassland[a]	0	0
Stenodes obliquana (Tortricidae, Lep.)	Halomorphic, saline semiarid grassland[a,b]	0	0
Aeshna subarctica (Aeshnidae, Odon.)	Boreal relict peatbog[c,d]	0	0
Carabus menetriesii (Carabidae, Col.)	Boreal relict peatbog[c,e]	0	0
Coenophila subrosea (Noctuidae, Lep.)	Boreal relict peatbog[c]	0	0
Pediasia truncatella (Crambidae, Lep.)	Boreal relict peatbog[b,c]	0	0
Hydrophorus signiferus (Dolichopodidae, Dipt.)	Boreal relict peatbog[f]	0	0
Molanna nigra (Molannidae, Trichop.)	Glacial lake[d]	0	0
Xestia sincera (Noctuidae, Lep.)	0? (bog margins)	Isolated natural water-logged boreal spruce forest[b]	0
Osmoderma eremita (Cetoniidae, Col)		Old lowland deciduous forest[b]	0? (groups of old deciduous trees)
Cerambyx cerdo (Cerambycidae, Col.)		Old lowland deciduous forest[b]	0? (groups of old oaks)
Xylomya maculata (Xylomyidae, Dipt.)		Old lowland deciduous forest[b]	0
Euphydryas maturna (Nymphalidae, Lep.)		Wet lowland deciduous forest[b]	0
Eurythyrea austriaca (Buprestidae, Col.)		Old montane mixed forest[b]	0

(continued)

Table 13.1 (continued)

Species	Paleorefugium	←Transitory habitat→	"Man made" neorefugium
Xyleborus pfeili (Scolytidae, Col.)	Old alder carr forest (minerotrophic wetland)[b]		0
Phragmitiphila nexa (Noctuidae, Lep.)	Old alder carr forest (minerotrophic wetland)[b]		0
Saga pedo (Tettigoniidae, Ensifera)	Xerothermic natural grassland and ecotones to "forest-steppe" (mostly limestone or volcanic substrate)[b]		0
Thereva eggeri (Therevidae, Dipt.)	Xerothermic natural grassland and ecotones to "forest-steppe" (mostly volcanic substrate)[g]		0
Meloe variegatus (Meloidae, Col.)	0?	Dry grassland and forest/grassland ecotones[b]	
Archanara dissoluta (Noctuidae, Lep.)	0	0? (minerotrophic wetland)	Reed communities of lake and constructed ponds[h]
Tibicina haematodes (Cicadidae, Auchen.)	0	0?	Vineyard plant communities[b]
Maculinea arion (Lycaenidae, Lep.)	0	0? (grassland-open forest ecotones)	Traditional man-made grasslands, pastures and ecotones[b]
Zerynthia polyxena (Papilionidae, Lep.)	0	0	Vineyard weed and neophytic communities with *Aristolochia*[b,i]

[a]Kasy (1981), [b]Škapec (1992), [c]Spitzer and Danks (2006), [d]Soldán et al. (1996), [e]Bezděk et al. (2006), [f]Olejníček and Spitzer (1984), [g]Barták and Kubík (2005), [h]Spitzer and Jaroš (2008), [i]Baumann (1981) (?: identity of refugium not clear)

in western Europe. The Large Blue and many other butterfly taxa are not threatened in eastern Europe and other parts of its global Palearctic geographic range (see Tshikolovets 2003 with bibliography from eastern Europe and western Siberia). The importance of the enthusiastic ‘butterfly approach’ as an avenue to publicising insect conservation needs in anthropogenic landscapes of central Europe emphasises dependence on traditional management of grasslands and the conservation importance of the agricultural old technology (Blab and Kudrna 1982 in Germany and Gepp 1983; Pils 1994 in Austria). Such conservation strategy and legislation is very difficult in any European landscape dominated by modern intensive agriculture (outside nature reserves), where even common opportunistic butterflies are in decline and their survival highly limited (Van Dyck et al. 2009 in western Europe). The most charismatic insects (mainly butterflies and some diurnal moths) of the man-made agriculture landscape are habitat protected in various types of nature reserves and conservation areas without special or informed management beyond basic protection from major disturbances. Recent population declines outside reserves are evident (Conrad et al. 2006 in the United Kingdom, Spitzer and Jaroš 2008; Thomas et al. 2009) and in some places are leading toward wider emphasis on integrating landscape–level conservation management. The most symbolic butterfly of European conservation projects seems to be the Apollo (*Parnassius apollo*) which is widely distributed in many central highlands of the European continent, but locally extinct in most places below the tree-line in neorefugial habitats (traditional pastures and ecotones of forest-grasslands) endangered by afforestration and perhaps by impacts of climate change (e.g. Palik 1981; Dabrowski and Krzywicki 1982; Wells et al. 1983; Van Swaay and Warren 1999).

13.4 Conclusions for Future

There is no protection of a species without the protection of its habitat. (A. Hausmann 2001)

The central European region is an important diverse biogeographical crossroad, where the ancient paleorefugial systems (alpine tundra and treeline, old natural forests, peatlands, minerotrophic wetlands, dry and halophytic grasslands) represent unique biotopes as basic priorities for insect habitat conservation. With respect to species conservation approach, the paleorefugial species with small geographic range and central European endemics should be given priority. Lists of many bioindicator flagship and/or umbrella insect taxa are already available – a few selected charismatic species examples are noted in Table 13.1, but these are simply representative of much wider need. The old traditional anthropogenic habitats are difficult to conserve and specific management of traditional agriculture technology is badly needed for old types of grasslands and pastures – but it is unfortunately not very realistic under modern impacts and rapid change of the agricultural and industrial landscape in most of Europe. But a large part of the relatively opportunistic insect fauna of the traditionally managed biotopes survive in natural reserves and ecotone habitats of paleorefugial and intermediate (transitionary) protected localities, where the anthropogenic impacts are limited by natural development and sometimes by special 'green' management sympathetic to conservation needs. The sufficiently large natural paleorefugial and transitionary reserves of various types of protection and management (starting from the most important "no action management strategy" for of the most natural, unique and very valuable biotopes) seem to be evident also from the conservation legislation of most central European countries.

Habitat conservation by a network of nature reserves (conservation areas), large national/natural parks and biotopes of Natura 2000 seems to be the most constructive basic priority approach to conservation of threatened insect populations and metapopulations. All nature reserves in central Europe and their legislation are based predominantly on ecosystem/vegetation characteristics, in some case augmented by needs for unique or unusual insect taxa (which depends whether sufficient background information on the local insect fauna is available), but there are no special entomological reserves established from conservation entomological point of view alone. Outside such a network of habitat conservation, the survival of central European endangered and rare insects is very limited or impossible: impacts of modern agriculture, urbanisation (residential development) including even creation of the "green desert" by lawn establishment and regimes of very intensive grass-cutting. Unnatural forest plantations and exploitation of mineral resources (e.g. limestone and peat) represent one of the most important threats generally.

A solution to the problem of impact of global climate change needs long term monitoring of insect communities within the ecological succession of other associated biota. For nature reserves see results of the most comprehensive survey by Spitzer and Jaroš (2008, with bibliography) after 28 years of monitoring of more than 900 highly stenotopic and also opportunistic species of moths ('r-K continuum' – limits of the moth metacommunity) associated with a minerotrophic wetland called Černiš in Czechia. The most characteristic (in Černiš common) "umbrella" species is the charismatic noctuid moth *Phragmitiphila nexa*, which is also included in several central European Red Books (Škapec 1992). Ecological changes in this habitat have been extremely small and all such flagship moths survive in the diverse complex of the wetland microhabitats (Spitzer and Jaroš 2008). Analogous data are available also from other habitat islands, where ecological succession is very slow and no change in survival of the bioindicator species is evident. It seems to be highly probable (Lozan et al. 2009 and unpublished) that during global warming periods such change should not only affect quality of the habitat (such as hydrological conditions) but especially support by side effects new invasions of opportunistic ("r-strategic") insect species (including possibly threatening parasitoids such as generalist Braconidae) to small and disturbed habitat islands of 'coldlands' of peatbogs and similar or analogous isolated biotopes. In population decline of some endangered species of already disturbed habitats, a kind of rehabilitation management is necessary, perhaps by planned long-term restoration of key vegetation and later re-introductions of some key insect species. The evident conclusion is that insect communities of large and well preserved natural ecosystems with diverse microhabitats are likely to survive temporary "global climatic change" and some natural successional developments of the system.

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Chapter 14
Development and Future of Conservation Policy Initiatives for Insects and Other Invertebrates in Europe

John R. Haslett

14.1 Introduction

The insect fauna of Europe and indeed the entire invertebrate fauna of the region have been subjected to an immense variety of severe changes of environmental conditions, habitat suitability and other threats to their existence, through their recent geological history to present time scales that encompass influences of human activities. Most of these animals also remain at the bottom of the league in public profile and conservation status in modern European society and environmental policy.

The Pleistocene ice ages destroyed a considerable portion of the original European fauna, initiating a biogeographical and evolutionary restart, that gives the fauna a much shallower geological history in comparison to faunas of the southern hemisphere. This difference has led to the observation that for many northern hemisphere scientists, the overall biodiversity of the southern hemisphere appears much more 'extravagant' (Cranston 2009). In fact, notions about the origins and composition of the present European invertebrate fauna are variable, depending on the part of Europe considered. Thus it has been observed that the insect fauna of northern Europe, including Fennoscandia and eastwards into Russia, is made up of mainly of widely distributed species (Holarctic, Palaearctic) and includes relatively few endemic species (Mikkola 1991). By contrast, the present insect fauna of the Mediterranean basin is the result of a complex mix of paleo-geographical and paleo-climatic influences, with a considerable portion of endemic species. This accentuates the role attributed to the Mediterranean area as an important and complicated set of refuges in which species survived the climatic changes of the Pleistocene, but are now in some cases confined to relic populations (Balletto and Casale 1991).

J.R. Haslett (✉)
Division of Zoology and Functional Anatomy, Department of Organismal Biology, University of Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria
e-mail: john.haslett@sbg.ac.at

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Humans began to exert a strong influence on the post-glacial landscape during the Neolithic, around 6500–4000 BC. Large areas of the original, often primary-successional woodlands and grasslands were converted to a land cover strongly reflecting human usage. Woodland clearance to provide space for agriculture and then management of those forests that remained are both thought to have had major detrimental effects on the woodland invertebrate fauna, particularly the saproxylic species (those species that rely on, directly or indirectly, dead or dying wood during all or part of their life cycle), with many species becoming extinct (Warren and Key 1991). Such massive changes to the vegetation must have also affected all the other components of the European invertebrate fauna.

By about 700 BC, the process of urbanisation began to spread across Europe, beginning in the south east with the Greeks and Romans (Antrop 2004). Cities were founded and transport networks were formed. This marks another major and continuing impact on the landscape: Urbanisation defined the relation between town and countryside and further reduced and fragmented the mosaic of more natural land cover patches. Again, this must have had considerable effects on the distributions of most organisms, including the invertebrates.

Landscapes continue to change rapidly throughout Europe. It is not only the speed of the changes, but also their frequency and magnitude, that have been increasing in an unprecedented manner since the middle of the twentieth century (Antrop 2004). Intensification of agricultural practices and at the same time marginalisation of the less favourable and less profitable agricultural areas, together with modern forestry management and the complex spectrum of urbanisation processes, mean that a multitude of new and old landscape elements are being continuously superimposed on one another in an ever-shifting dynamic mosaic of land use and cover. But all are linked in a chronological order, so that it has been said that landscapes have 'memory' – present landscape characteristics include elements and patterns inherited from previous land use and management strategies (Haines-Young 2005).

With all these continuing changes to their habitats, it is not surprising that the entire spectrum of species and populations that make up Europe's ecosystems now seem to be fighting a losing battle to try to keep up the necessary pace for survival – they must adapt or move, or they become extinct. And it is the smaller, less vagile species that are most at risk, which includes the majority of the invertebrates (e.g. as noted for the European woodland invertebrate fauna, Warren and Key 1991).

Modern conservation biology recognises this suite of problems that comes from consideration of the spatial axis of ecosystems. Embedded in the formal frameworks of landscape ecology and (meta) population biology, now-familiar terms such as habitat loss, fragmentation, isolation and minimum viable population size are only some of those that reflect the negative impacts of humans on the living space of other organisms. Just as importantly, policy and management strategies for conservation have responded by acknowledging the importance of not only designating and managing protected areas (PAs) and their surrounding buffer zones, but also the establishment of ecological networks that include corridors and stepping stones to link such refuges across larger areas.

In addition to these spatio-temporal issues, however insects and other invertebrates face a further major problem: Worldwide, these organisms have been largely ignored or forgotten about in the relevant decision-making for biodiversity conservation and land-use planning and in the practical implementation of land use and conservation strategies and management.

Although this problem is general, it can be all too tempting to think that at least in Europe, maintenance and protection of present insect and other invertebrate biodiversity must be rather efficient and successful. Indeed, there is a long tradition of zoology and entomology in many European countries that has provided a wealth of information on the species and their distributions, there is widespread public awareness of the concept of nature conservation, and a pan-European infrastructure exists with the capacity to coordinate conservation effort and financial and human resources. But the reality is that in 2002 IUCN, The World Conservation Union, formally recognised that biodiversity conservation in general was inefficient across Europe (see commentary by Haslett 2002) and that new efforts and approaches were required. Independently, but at about the same time, the Council of Europe noticed that invertebrate conservation in Europe was seriously lagging behind conservation efforts for birds, mammals and plants and began to think about how to redress the situation.

In the remainder of this chapter I give my own account of some of the ups and downs in the development of modern legislative frameworks for European invertebrate conservation and I examine some of the implications for the future successful protection of invertebrate biodiversity in Europe. In line with the overall theme of this book, I pay particular attention to insects, but as previous authors have already observed, it is impossible to isolate insect conservation from the conservation of other organisms, whether animals or plants. Many of the principles and much of the legislation involved at the European level are not confined to insects, but apply to most terrestrial and freshwater invertebrate groups (e.g. Collins 1987; Usher and Jefferson 1991).

14.2 A Progression of European Policy Instruments and Initiatives and an Important Shift in Emphasis

The serious beginnings of present day conservation biology policy in Europe started to unfold during the 1980s and involved particularly the activities and initiatives undertaken by the Council of Europe in Strasbourg, France. On 19th September 1979, after some 3 years of drafting, the 'Convention on the Conservation of European Wildlife and Natural Habitats' was opened for signatures of member states. The announcement was made at the beginning of the 3rd European Ministerial Conference on the Environment, in Bern, Switzerland. The 'Bern Convention' as it is now widely known, came into force in 1982, and has since proved to be one of the most important instruments for present biodiversity conservation across Europe (Council of Europe 1982). However, in those early years, for me and for many other entomologists, the Convention appeared to be of only marginal interest, as no specific provision was made for protecting any species of invertebrates. In fact, there had apparently been enough problems during drafting in dealing with international disputes about which bird species needed protection or issues arising from the hunting of large carnivores. All this with the added complication that the European Commission in Brussels was in the process of drafting its Directive on the conservation of wild birds (79/409 CEE) at just the same time (European Commission 1979 and see commentary by Ribaut 2004). (It is worth stressing here that the Council of Europe, with its secretariat in Strasbourg, France and presently 47 member states, is not at all the same as the European Union (EU) based in Brussels, Belgium and with presently 27 member states. The EU as an entity is itself a contracting party to the Bern Convention. It is surprising how much confusion this difference has caused in the past and continues to cause now).

Although invertebrates were missing from the Bern Convention in the early years – it took until 1988 for a few species of insects, molluscs and others to be included, see below – this did not mean that they were being completely ignored by the Council of Europe. A group of specialists on invertebrates had been established and in 1983 its members put forward and discussed a proposal for a European 'Charter on Invertebrates' which was finally adopted by the Council of Europe Committee of Ministers and published in 1986 for distribution to the (then 21) member states (Pavan 1986). The Charter focuses on the reasons for protecting invertebrates but does not suggest ways of how to go about such protection. Thus, sections cover numbers of species and biomass, positions in food webs, sources of human food, soil formation, biological pest control, use in medicine and industry, aesthetic value and more. In retrospect, the Charter may now seem very old fashioned, even primitive in its presentation, but it clearly demonstrated that at least some attention was being paid to invertebrate conservation needs at the pan-European level.

A year later, in 1987, IUCN took the initiative by publishing, in conjunction with the Amateur Entomologists' Society in Britain, a catalogue-style summary of the available legislation to conserve insects in Europe, both internationally and by individual country (Collins 1987). This document well illustrates two very important aspects of insect and other invertebrate conservation policy in Europe at that time: (i) it was species-based (ii) it was designed and executed at the national (or sub-national) level – there was little or no co-ordination between countries. Also, to make matters worse, the then eastern block countries in Europe did not recognise western European conservation instruments, including the Bern Convention (Boere 2004). These factors, acting singly and together, were to prove to be major stumbling blocks in advancing the cause of European invertebrate biodiversity conservation.

The strong scientific and legislative emphasis placed upon conserving particular species (even if the words 'and habitats' were sometimes tacked on to the end) was associated with a proliferation of 'Red Lists' of species deemed to warrant particular conservation effort appearing in the literature. This was the state-of-the-art at the time and the strategy was applied to all organisms, from birds, mammals and plants to insects and other invertebrates. In Europe, lists covering particular groups of invertebrates were published at national, sub-national and local levels in many countries. These lists were most often compiled by local specialists in the different groups writing in their own language and usually reflecting personal subjective judgements and definitions. There was often some effort to apply the set of formal categories defined by IUCN at that time to distinguish different degrees of rarity and threat but these categories were themselves highly subjective. There was insufficient communication between workers and little or no standardisation across invertebrate groups or across geographical areas of widely differing spatial scales. At the other extreme and at the same time, attempts were being made to create red lists at pan-European to global levels and involving many groups of invertebrates, but these too suffered from some important conceptual problems. For example, in 1983 IUCN published an 'Invertebrate Red Data Book' (Wells et al. 1983) that attempted global coverage and listed selected species representing most of the classes of invertebrates, from protozoans to echinoderms. This list also included a few insects and other invertebrates occurring (though not necessarily endemic to) Europe, such as the European species of Large Blue butterfly (listed as four *Maculinea* species), the Apollo butterfly (*Parnassius apollo*), five species of European wood ants (*Formica* spp.), a couple of dragonflies (Odonata) and a few others. Of particular relevance here is that the number of species included was much too limited to be representative and the selection process itself was again highly subjective, using the unclear IUCN categories and criteria of the time. However, the Invertebrate Red Data Book, including its documentation of information on each species (the 'species accounts' or 'data sheets') heralded some much needed good news for invertebrate conservation in that it began to transmit the message that invertebrates warrant conservation attention just as much as mammals and birds (the 'furries and featheries', May 2007) and flowering plants. Importantly for Europe, the book provided a stimulus and helped to provide a template for the next round of species-focussed invertebrate protection legislation at the pan-European level.

The Council of Europe was at the time encouraging work on invertebrate conservation from different angles. First, through its publications on particular groups, such as the pioneering work on the threatened butterflies (Rhopalocera) of Europe (Heath 1981) using the 'data sheet' approach and a similar style report on Odonata (van Tol and Verdonk 1988). Second, through the formation and activities of a Group of Consultants (now called the Group of Experts) on the Conservation of Invertebrates, which was given its terms of reference in 1983 and answers to the Standing Committee to the Bern Convention. Third, through initiating a proposal for some invertebrate species to be included in the Appendices of the Bern Convention (Collins and Wells 1987). The primary focus of all of these activities was still clearly species conservation and all were all closely intertwined.

The threatened butterflies document provided the initial impetus for the Group of Consultants to discuss and suggest first the inclusion of a few species of butterflies, then expanded to other insects, and then invertebrates in general, in the Bern Convention Appendices. This entire process was fraught with difficulties, from late submissions that could not be formally considered, to doubts about the appropriateness of the timing of the alterations to the Appendices, to questions about the national legislative practicalities involved in adding even a small number of species (Collins and Wells 1987). The IUCN Conservation Monitoring Centre, based in Cambridge, UK, was engaged to act as consultant in 1984 to investigate the situation of the most endangered insects in Europe. The report subsequently provided was then revised and expanded at the request of the Council of Europe in 1986 to include invertebrates other than insects. The resulting document, again in data sheet format, was then published by the Council of Europe (Collins and Wells 1987) and adopted as the basis for additions to the Bern Convention Appendices.

The insects and other invertebrates that eventually made it onto the Bern Convention Appendices in 1988 were placed mostly in Appendix II 'Strictly protected fauna species' with one or two in Appendix III 'Protected fauna species'. The species selected were inevitably a direct result of the processes and history I have just outlined, including some errors and many imperfections. These were to provide a source of distinctly animated discussion within the early meetings of the Group of Experts and other meetings over the following years. Realising that the Stag beetle (*Lucanus cervus*) or the Apollo butterfly were really rather widespread and in some places common and not under any immediate threat at European to global levels was appeased by the argument that such flagship species are widely recognised by the public and are actually an essential ingredient in successful conservation strategy. But scientific arguments over the wisdom of including a relatively large number of land snails (Mollusca) endemic to the island of Madeira were exacerbated when it was pointed out that in addition to the over-representation, some of the species names were invalid, and that at least one snail had not been reported as still in existence for over a century (Wells and Chatfield 1992).

Despite these and other frustrations, a general acceptance was reached by members of the Group of Experts that the lists, having been created so recently, could not be changed easily in the near future and there was a consensus that a positive approach was needed to make the best of the species list as it stood, by asking how the designated invertebrates could be used to greatest advantage in promoting invertebrate conservation in general within the remit of the Bern Convention and beyond. An obvious first step was to update and expand the data sheet information on the biology and conservation status of each species across Europe. This task was contracted to the European Invertebrate Survey (EIS), Netherlands, which then recruited experts with pan-European experience to assemble and collate the information on each species in a standardised format. This also included the identification of priority actions necessary for future successful conservation. But already there was a new and very significant complication, that the European Commission had drawn up its 'Habitats Directive' with Annexes that also listed invertebrate species in need of protection (European Commission 1992). The species involved were those on the Bern Convention Appendices, but with a few additions. It appears that because the European Union had ratified the Bern Convention it was obliged to introduce appropriate legislation to honour its obligations and it used the Habitats Directive to do this in respect of the Bern Convention invertebrates. But it also became apparent that the list of the Bern Convention was not entirely appropriate for the purposes of the Habitats Directive (van Helsdingen et al. 1996a). Thus the set of 85 species data sheets that finally appeared addressed those species on Annex II (species that require the designation of reserves) and Annex IV (species in need of strict protection) of the Habitats Directive and was published in three volumes by the

Council of Europe (van Helsdingen et al. 1996a, b, c). In a short statement in the introductory text to the data sheets, these authors refer to the 'awkwardness' of the selection of species and expressed 'hopes that any future additions to the Annexes will be considered very carefully' (van Helsdingen et al. 1996a). In fact, the interdependence of the Bern Convention and Habitats Directive invertebrate lists made any further changes or additions extremely difficult and most unlikely because of the different interests and political red tape involved (van Helsdingen 1997).

While all this lamentation, discussion and debate about species lists was going on during the late 1980s and through the 1990s, changes in attitude were developing in the politics and implementation of nature conservation at the Council of Europe and also in other non-governmental and governmental organisations. The habitat protection aspect of conservation was gaining considerable impetus.

In 1979, the Birds Directive of the European Commission (European Commission 1979) had made specific provision for the creation of a system of 'Special Protection Areas' to maintain populations of bird species. In doing so, the Directive addressed an important trans-border issue of nature conservation across Europe, that is enforced (and punishable) by hard law. Although the full implications of this for more general pan-European biodiversity protection were not taken up immediately, the document formed part of a new and major shift in emphasis, from particular species to habitat and ecosystem protection. The trend gained momentum, fuelled by a variety of complex interactions involving global, European and national, sometimes also local initiatives and ideas. The almost token inclusion of the word 'habitats' in other European conservation legislation, including the Bern Convention, would later take on a new significance. The adoption of the European Commission Habitats Directive in 1986 and extended by the Maastricht Treaty in 1991 (European Commission 1992) gave further credence to habitats and protected areas and allowed the EC to further implement the Bern Convention to cover plants and animals other than birds (also including insects and other invertebrates) (Machado 1997). All this was bolstered by the global impact of the Convention on Biological Diversity (CBD) in which Article 8 on *in situ* conservation made clear the importance of protecting biodiversity within designated Protected Areas and also across the wider landscape. A direct Pan-European response to the requirements of the CBD was to develop the Pan-European Biodiversity and Landscape Diversity Strategy (PEBLDS) (Council of Europe 1996; Bonnin et al. 2007) and within this Strategy, to establish a Pan-European Ecological Network (PEEN), involving specifically the creation and management of core protected areas surrounded by buffer zones and linked across the wider landscape by ecological corridors (Council of Europe 2000a). A further outcome of this has been the establishment of the present Natura 2000 network within the EU States under the Habitats Directive and as part of the wider Emerald Network of PAs organised by the Council of Europe under the Bern Convention to include member states outside the EU (Recommendation Numbers 14, 15, 16 (1989) adopted by the Standing Committee to the Bern Convention and see Standing Committee to the Bern Convention 2000). Importantly, PEBLDS includes a mechanism for maintaining ecological integrity also outside PAs, a strategy that stresses the preservation of ecosystem function across wider landscape mosaics (for a recent definition and commentary see Harrington et al. 2010). The concept can be usefully linked back to the reality of complex land mosaics with a human history across Europe as described at the beginning of this chapter, and could be potentially further supported by the European Landscape Convention (Council of Europe 2000b, 2002).

So, with such a great flurry of activity involving habitat and PA legislation, which flowed into the new Millennium and affected an ever greater geographical area in Europe as new member states continued to be added to the EU and/or the Council of Europe, where did this leave European invertebrate conservation? Sadly, still with a raw deal, by continuing to be mostly ignored or grossly under-represented. Scientifically, it could have been possible to argue strongly for specific measures to maintain invertebrate biodiversity as an obvious and essential 'bird food' within the Birds Directive, but this and other such forms of integration with the different initiatives and strategies did not happen. The time was not ripe. Instead, there was (and still often remains) the widespread, but mistaken belief that if an area is protected and managed to look after the birds, larger mammals and maybe some plant communities, then the smaller organisms, including the invertebrates, should be also automatically protected. I was directly confronted with just this type of large landscape scale 'blanket management' strategy when I went to work at the Berchtesgaden National Park in the Bavarian Alps in Germany for a few years in the mid 1980s.

The Berchtesgaden Park, which then as now provides one of the leading examples of innovative conservation research and management in Europe, was at the time enjoying considerable UNESCO financing under the Man and Biosphere Project 6 programme. A vector based Geographical Information System coverage of the entire National Park and buffer zone had just been developed and was up and working, the first such facility anywhere in Europe. Its potential to aid spatially referenced ecological (and other) research was only beginning to be recognised (Haslett 1990a). But despite this cutting edge new technology and research, which did also include a small amount of work on insects and some other invertebrates – mostly simple collecting from different habitats and land cover types, the management strategy for conservation for the area was firmly based on managing large scale human land use with priority protection of a small number of key species. Agricultural and forestry practices, regulation of deer (and other) hunting, recreation, tourism (etc.) were all executed with an underlying view particularly to protect rare and/or charismatic birds such as golden eagle, capercaillie, black grouse and ptarmigan and mammals such as chamois, ibex and snow hare, and also maintaining broad vegetation/plant community types and rare or characteristic plant species such as orchids and gentians. It was fully expected that insects and other invertebrates would 'fit in' and be well protected by this strategy. Indeed, assuming the effectiveness of such passive protection meant that the amount of information available on the invertebrate fauna relevant to active management for its conservation within the National Park and buffer zone was minimal. It was not even known exactly how many and which of the invertebrate species listed in the Bern Convention Appendices occurred in the area, and for those that had been clearly documented (six butterfly species and one land snail), particular habitat requirements were incompletely known and there were no specific protection strategies in place.

I presented this situation as a case study at a combined European Invertebrate Survey and Council of Europe colloquium on the conservation of Bern Convention-listed invertebrates at the time (Haslett 1990b). At the meeting, discussions soon revealed similar assumptions of passive blanket (or umbrella) management for invertebrates in other countries. Clearly, there was an urgent need to give the protection of invertebrates, including their habitat requirements, a higher profile within and also outside protected areas in Europe.

Throughout this period, the legislation that did exist to target active invertebrate conservation remained species-based and organised at the national or, in some countries, local government level. Each country had (and presumably still has) its own, often apparently haphazard and inadequate red list of a few species, mostly insects, deemed in need of protection by whatever local authority or opinion (Collins 1987). In his introductory text, that author noted that 'the vast majority of endangered insects is threatened by loss or deterioration of habitat'. However, in the same text, Collins also noted that most of the national legislation reviewed in the document 'consists of lists of threatened species to be 'protected' from collectors' and this danger was attributable to 'the small number of collectors who behave irresponsibly.' While over-collecting certainly has been and remains a threat to some invertebrate species in particular instances in Europe, it is now recognised as very minor in comparison to habitat loss and other environmental change, also at global levels (Morris et al. 1991; Samways 2005). However, the inconsistency between identifying major threats and prioritising and undertaking appropriate actions was a reality and is a further aspect of the confusion surrounding invertebrate conservation strategies and legislation at that time.

As a result of all these different interests and influences, the 1990s proved to be a period during which European invertebrate conservation followed a rather erratic course, trying to maintain a hold on species protection while also recognising the increasing scientific and political necessity to adopt a more habitat and protected area approach. Effort was still directed at particular species and taxonomic groups and included the discussion and publication of documents addressing the conservation of aculeate Hymenoptera in Europe (Day 1991), threatened non-marine molluscs (Wells and Chatfield 1992) and an updated and modernised red data book of European butterflies (van Swaay and Warren 1999) to supplement the work on the Bern Convention/Habitats Directive species lists referred to previously. There was also work to develop 'Action Plans' for the recovery of particular endangered species in Europe, e.g. Large Blue butterflies (*Maculinea* spp.) (Munguira and Martin 1999). But parallel to this, the Council of Europe began to encourage and support initiatives with a distinctly biotope or habitat protection approach. One of the first, and probably still the most successful and influential of such initiatives addressed the importance and conservation requirements of saproxylic invertebrates (Speight 1989). The work was to prove to be a key contribution to invertebrate conservation and has been adapted and applied in many European countries. Importantly, it showed quite clearly that habitats or biotopes may not be considered as being synonymous with vegetation cover types as was the common practice – other habitat elements (here rotting wood) are equally, or even more important for the survival of many species.

Other habitat oriented initiatives followed. A joint effort from the Secretariats of the Bern and Ramsar Conventions focussed on conserving and managing wetlands for invertebrates (Council of Europe 1992). A subsequent study identified biotopes of particular significance for invertebrates, ranked by the presence of threatened, endemic and highly specialist species of a variety of groups (Koomen and van Helsdingen 1996). A colloquy on the conservation, management and restoration of habitats for invertebrates was held in conjunction with the 4th meeting of the Group of Experts on Invertebrates in Killarney, Ireland (Council of Europe 1997a). Similarly, a Workshop on ecological corridors for invertebrates was organised in combination with the 6th meeting of the Group of Experts in Neuchâtel, Switzerland (Council of Europe 2000c). A review was also published on European underground habitats and their protection which, although not aimed specifically at invertebrates, certainly highlighted the major relevance for below-ground invertebrate faunas (Juberthie 1995).

All of the above works 'went through the system' of the Council of Europe and for many (but not all) this resulted in the drafting of Recommendations that were officially adopted by the Standing Committee to the Bern Convention for circulation to the governments of member states (which, remember, also includes the European Union). This mechanism provides a formal legislative backing that is essential for implementing the conservation measures and strategies concerned. Full texts of all such Recommendations have been published by the Council of Europe (1997b, 2001, 2005, 2009).

However, even with all these apparent advances, the general mood of the meetings of the Council of Europe Group of Experts was of some uncertainty and growing frustration – invertebrate conservation in Europe was still not very effective and was not progressing in comparison to protection strategies for other groups of organisms, even plants! Looking back at the official reports of the meetings prepared by the Secretariat and also my own notes, the acknowledgements of numerous small achievements were punctuated by stark reminders of the major problems being faced. Thus, in the opening remarks of the Colloquium at the Killarney meeting in 1996, the Secretariat of the Council of Europe stressed the problems of attracting attention to the importance of invertebrate conservation, in terms of both public interest and EU funding and suggested that reference to invertebrate *biodiversity* conservation, rather than single species protection might provide a broader acceptance in the future. Coming from the Secretariat, this was significant, because it was somewhat different to the strategy of species protection that was then being implemented under the Bern Convention.

At the next meeting of the Group in 1998 the chairman, in summarising the presentations and discussion of individual national reports on progress in invertebrate conservation, noted that there appeared to be indeed little progress in creating interest from national governments or other official bodies. Many hopes seemed to rely on the future development of the NATURA 2000 and Emerald networks of PAs.

Two years later, at the Group of Experts meeting in Neuchâtel in 2000, the presentations and discussions at the associated Workshop on ecological corridors for invertebrates sent out a strong message that in many instances, ecological corridors do not fulfil their purpose – they do not always facilitate directional movement of the organisms to aid their dispersal and colonisation across the landscape. Or if they do, the movements may occur over such small distances and such long time periods as to render the effects irrelevant for contemporary invertebrate conservation purposes (see the Workshop proceedings, Council of Europe 2000c). These conclusions were not exactly in line with what the Secretariat of the Council of Europe had expected, or indeed wished for, given that the future of nature conservation in Europe was now heavily committed to the protected area/corridor networks of NATURA 2000 and Emerald initiatives. However, within the official meeting of the Experts' Group, a consensus was soon reached that ecological corridors are good thing in principle, but much more research and refinement of the concept is required for purposes of invertebrate conservation. So, the situation was rescued and placed on hold! But during the same meeting came the news from the Secretariat that the Council of Europe was undergoing major internal organisational changes, affecting the administration of all matters concerning the Bern Convention. The upshot of these changes for the Group of Experts was that although the Group would continue to exist (with future meetings on an *ad hoc* basis), the mechanisms of future administration were uncertain. Later in the meeting, in the shadow of this uncertainty, the Chairman of the Group noted that although there appeared to have been an overall improvement in coordination between scientists and governments within countries, there was still a severe lack of international cooperation. In other words, Council of Europe backup was showing signs of stress just at the time when invertebrate conservation needed a strong injection of pan-European coordination.

The Group of Experts meeting in 2003, held in Cardiff, UK, proved to be pivotal for invertebrate conservation at the European level, but only very late in the proceedings. There was the (now customary) open colloquium, with a theme this time reverting back to red lists of species and their application for conservation at different spatial scales. Discussion included the problems of applying the then 'new' IUCN Red List criteria (IUCN 2001) to invertebrates.

In the formal meeting of the Group of Experts, there was the usual report from the Secretariat, this time stressing the difficulties of the continued survival of the entire Council of Europe within a Europe that is increasingly being ruled from the EU in Brussels, such that Council of Europe business now requires stronger emphasis on political aspects. The Secretariat also admitted that the general reluctance of the Council of Europe to make changes to the Bern Convention Lists of invertebrates was a direct consequence of the strategy to promote the Natura 2000 network of protected sites, giving priority to habitats/biotopes.

The Expert Group accepted this information, but with more than a little frustration, as it meant that all previous time and effort invested in trying to modernise the species lists had been wasted. Such work had actually reached the stage of a formal report, requested by the Secretariat, with suggestions of additions to the invertebrate species listed in Appendix II of the Bern Convention (Council of Europe document T-PVS (98) 9). That document had been discussed at the 1998 Experts' meeting and as a result had been supplemented by a further working document to extend the suggestions to cover southern and eastern Europe (Council of Europe document T-PVS (99) 41), all to no avail.

The remainder of the Experts' meeting was uneventful, until near the end of the day, tucked in at the bottom of the agenda, an item was reached that the Secretariat had included as 'Conservation Strategy for Invertebrates in Europe'. With little time left for discussion, it was generally assumed by members of the Group that this was simply a point for defining how invertebrate conservation was going to progress in the light of the political and other pressures that had been stressed earlier in the meeting. Then someone noticed that the words as written on the agenda began with upper case letters. Upon being asked about this, the Secretariat confirmed that indeed, drafting a formal European Strategy was the intention. There was a need to have a formalised European Strategy for Invertebrates, similar to, for example the Strategy for European Plant conservation developed in collaboration with Planta Europa (Planta Europa 2002, 2008). A 'roadmap' for the conservation of invertebrates should be created, useful at the governmental level. The Group of Experts welcomed this suggestion and adjourned in a lighter mood. European invertebrate conservation had just entered an important new phase of development.

A month or two after the Group of Experts meeting in Cardiff, I received a telephone call from Eladio Fernández-Galiano at the Secretariat in Strasbourg. He needed someone to undertake the work of drafting the European Strategy for invertebrates: would I be available? I said yes.

14.3 The European Strategy for the Conservation of Invertebrates

To prepare a conservation Strategy that covers not only insects, but also the entire spectrum of (non marine) invertebrates and that should be applicable across Europe, with many geographical regions and political boundaries, was a responsibility that I could not shoulder without formal assistance of other experts with wide European experience. So a small advisory group of specialists was duly assembled by the Council of Europe and the work began.

It took almost 3 years to come up with a draft Strategy that I, and the advisory group and the Council of Europe Secretariat together considered suitable for presentation to the full Group of Experts on invertebrates for discussion. Of course throughout the entire project I was also greatly aided by very many other friends and colleagues – as the song says, 'I got by with a little help from my friends'. A meeting of the Group of Experts was held in June 2006 with the draft Strategy as the main item on the agenda. From the ensuing discussions, the text was then finalised. The Standing Committee of the Bern Convention adopted the Strategy at its meeting in November the same year. Through its Recommendation 120 (2006) the Standing Committee asked Contracting Parties to: *'(1) draw up and implement national strategies on invertebrate species, or other relevant measures, as appropriate, taking into account the European Strategy for the Conservation of Invertebrate Animals mentioned above; (2) cooperate as appropriate, with other Contracting Parties and observer States in the conservation of invertebrate species; (3) keep the Standing Committee informed of the measures taken to implement this Recommendation'*. The formal legislation was in place!

The Strategy was finally published by the Council of Europe in December 2007, (Haslett 2007), with messages of support provided in a message from Eladio Fernández-Galiano of the Secretariat of the Council of Europe, in a short Foreword by Sir David Attenborough and in a Guest Essay by Prof. Robert May, Lord May (May 2007).

So how can this new Strategy actually aid the protection of invertebrates in Europe? From its conception, a central idea behind the Strategy had been to provide a 'road map' to guide future needs and actions, targeted specifically at governments of all Council of Europe member states and other Parties to the Bern Convention, but also at all decision-makers, land managers, scientists and teachers that have potential influence on invertebrate conservation. The Goal of the Strategy is 'To halt the loss of invertebrate animal diversity in Europe'; in other words, to commit to giving the invertebrates a better deal in their struggle to survive than they have had in Europe to date. A number of general Objectives are defined to provide a logical path towards realising this goal and the remainder of the Strategy is designed to provide a 'toolbox' for invertebrate conservation and sustainable use. Key Actions are identified throughout to address issues of threatened species and red lists, but also widespread species and ecosystem service provision, habitat protection and management, indicators of biodiversity and monitoring, threats from invasive species and from agriculture, forestry, industry and urbanisation, sustainable use of invertebrates, scientific capacity building, education and public awareness and international cooperation and implementation issues. The Strategy is thus intended as a common framework that can be adapted to suit different needs in different countries. This requirement of flexibility was central to the design of the Strategy but was a source of difficulty, because the different needs and their priorities are so hugely variable. For example, in a country such as Spain, where many species of invertebrates are still being discovered as new to science (Fig. 14.1) and much basic biological knowledge is still missing, the priority conservation actions will have an emphasis on species inventories and basic biological research and so be rather different to the priorities in countries such as the UK and the Netherlands, where faunal inventories are much more complete and biological details are better known.

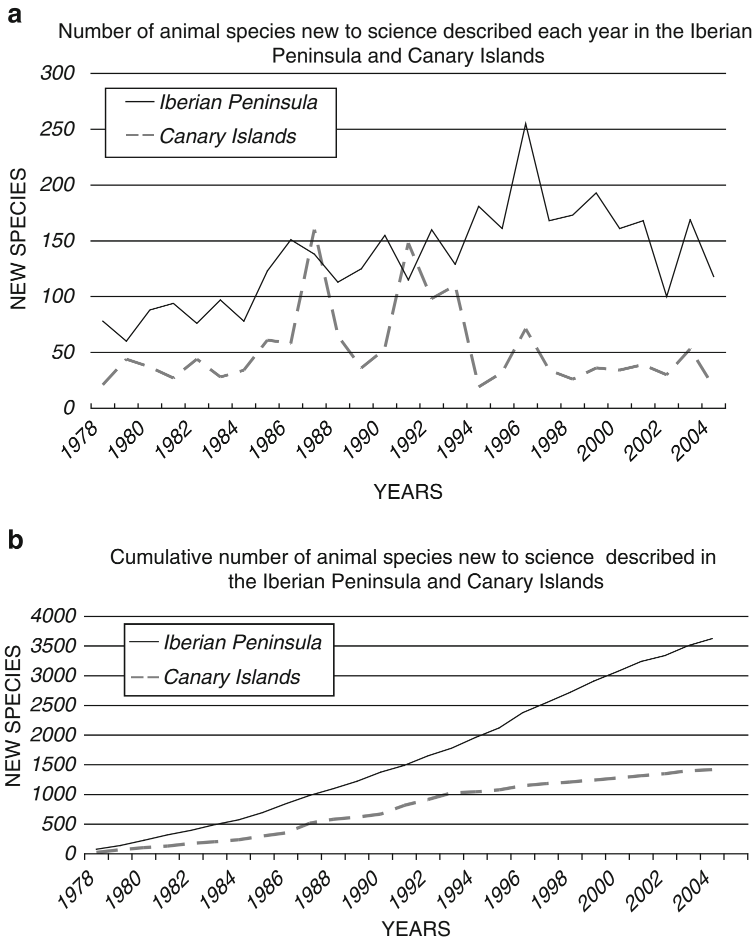

Fig. 14.1 Animal species new to science (mostly invertebrates) described from the Iberian Peninsula (continental Spain and Portugal and the Balearic Islands) and the Canary Islands. (**a**) Number of new species per year (**b**) cumulative totals show a rather constant trend of increase data collected by the Fauna Ibérica project (M.A. Ramos and J. Fernández). Reproduced from Haslett (2007)

14.4 Implementing the Strategy and the Future of Invertebrate Conservation in Europe

'*Imagine the scene*'. This is the title of a short article written by the late Cyrille de Klemm, a most eminent conservation lawyer (and often to be heard, if not easily seen, in his role as interpreter at Bern Convention and other Council of Europe meetings). The text was written originally in 1995, imagining that '*it is the early twenty-first century, 2010 AD or thereabouts*' and describing an ideal vision of nature conservation success in Europe. (The article was republished by the Council of Europe in 2004, as part of a special issue of Naturopa, marking 25 years of the Bern Convention: de Klemm 2004). Reading the piece now, at exactly the time of the author's projections, the clarity and accuracy of his perception are uncanny. The short paragraph that includes specific reference to invertebrates states: 'In the case of invertebrates, lower order plants and micro-organisms, and most of the marine organisms, which were practically disregarded for a long time, it has been possible to identify a fairly large number of endangered species and the habitats particularly favourable to them, and protective measures are starting to be taken.' Those protective measures are now encapsulated in the European Strategy, which indeed also provides a new starting point in that the future success of invertebrate conservation does not rely on simply the existence of a Strategy, but on its long term, effective implementation. This is not such an easy task, even if an essential one. For one thing, although the Strategy has the legislative support of a 'Recommendation' from the Standing Committee to the Bern Convention, this is really only 'soft law' except in some particular situations within the remit of the 'harder' EU Directives. Thus, Contracting Parties, particularly those outside the EU, may be less strongly committed to fulfilling their obligations than they should be, even though there are control mechanisms in place to try to ensure compliance. Here there are also clear implications for effective trans-boundary conservation management. Although the issue is a general property of much Bern Convention legislation, it is particularly problematic for the Invertebrate Strategy – the lack of public and political attention paid to these organisms means that if they are ignored in legislation, few people really notice or care.

This highlights again the urgent need to improve education and public awareness of the overall importance of invertebrates for ecosystem function, and also, somewhat more pragmatically, for the sustainable provision of ecosystem services (ES). These services are the benefits that people obtain from ecosystems that support, directly or indirectly, our survival and quality of life (see definition in Harrington et al. 2010). The Millennium Ecosystem Assessment (MA) (Hassan et al. 2005) distinguishes between four major classes of ecosystem services – provisioning services are the products obtained from ecosystems, such as food, water, fuel; regulating services are the benefits obtained from natural processes, such as air quality, water purification, pest control, pollination; cultural services are the non-material benefits, such as recreation and aesthetic enjoyment; finally supporting services, such as soil formation, nutrient and water cycling, are necessary for the provision of all other ecosystem services. Invertebrates play major roles in the provision of all four of these ES categories, and this provides a new and important set of arguments for their protection.

Until now, conservation of invertebrates and other organisms has been undertaken solely for moral, ethical, or aesthetic reasons – the 'cultural services' of the MA, but now there is a strong interplay between conservation and economic interests in all of the other MA service groups. Thus, viewed in a market framework, society depends on selected aspects of biodiversity in order to fulfil various physical needs. This infers that some sort of value must be placed on each service to allow choices, or trade-offs, to be made that take into account the costs and benefits. Giving economic values to ecosystem services is often difficult and controversial (e.g. see Haslett et al. 2010; Skourtos et al. 2010) but by identifying the importance of biodiversity and consequently, the cost of losing the services can provide strong arguments for the necessity for biodiversity conservation. As an example, the economic values of some ecosystem services provided by insects, such as pollination and dung degradation, have been estimated in the USA in billions of dollars (Losey and Vaughan 2006).

So, managing habitats and species to protect service provision, while at the same time meeting the needs of overall biodiversity conservation, may offer a potentially highly effective means of improving present habitat management strategies for biodiversity maintenance. In Europe, a framework that brings together the relationships between present conservation approaches and wider societal needs, the provision of ecosystem services and also the dynamics of ecosystems, including spatial land use change and climate change, has been developed by Haslett et al. (2010) within the European Commission RUBICODE project (www.rubicode.net). This integrative framework stresses that any ecosystem service provision approach to conservation could never replace present conservation management strategies, but that it does provide a 'value-added' strategy to complement and support existing, traditional biodiversity conservation. Application of such ideas to insects and other invertebrates as service providers, thus emphasising their usefulness in all types of ecosystem and across the different economic sectors would be a considerable aid to the implementation of the European Invertebrate Strategy.

The second important dimension of the framework, the inclusion of the dynamic nature of ecosystems, is rarely considered in traditional biodiversity protection legislation and is of particular relevance to the successful future implementation of the Invertebrate Strategy.

As mentioned previously, European landscapes are continuing to change rapidly because of human influences and now also the extra pressure of climatic change, which can affect the landscape directly or by influencing patterns of human usage. Given that under a warming climate in Europe, species populations may be expected to move regionally northwards and/or locally upwards (Thomas et al. 2006; Usher 2007) and that habitat mosaics will continue to change and fragment, this is likely to have severe effects on spatial patterns of invertebrate (and other) biodiversity and thus on protection requirements. This will affect particularly the (many) invertebrate species that are at the edge of their range, geographically localised, of low genetic diversity, slow reproducers, poor dispersers or highly specialised in their ecological requirements. Thus there is a necessity for great flexibility within conservation strategies and legislation to cope with situations of rapidly changing priorities. Even the presently designated protected areas in Europe may not always be in the right place under future scenarios and, remembering that most invertebrates view their landscapes at rather small spatial scales (e.g. Haslett 2001) this will have implications for the effectiveness for invertebrate protection of the NATURA 2000 and Emerald ecological networks that observe larger scale, static geographical boundaries.

Here again, application of the ecosystem service approach may prove beneficial in the future, as service provision will be required to move to track the changes across the landscape, and so must be protected without being within the boundaries of a defined protected area (Haslett et al. 2010). A further new framework, the Framework for Ecosystem Service Provision (FESP), which was also developed within the RUBICODE project, addresses the complex dynamics of such environmental change drivers and pressures and the internal and external perturbations within entire social – ecological systems (Rounsevell et al. 2010, and see Samways et al. 2010). However, both of these RUBICODE frameworks have yet to be tested on the ground and it is likely to be some time before such ES approaches will be accepted by European governments and incorporated into conservation policy.

Leaving the development of new innovative approaches aside, there is another major direction in which effort could be most usefully focussed to gain strong practical and legislative support for invertebrate conservation in Europe. There should be close coordination of the implementation of the Invertebrate Strategy with the implementation of other existing Strategies for other groups of organisms. The idea of integrating invertebrate protection with bird protection via the EU Birds Directive has already been mentioned, and the arguments for this remain valid, but at least equally, if not more relevant, would be close coordination with the European Plant Conservation Strategy (Planta Europa 2008). The close interdependence of invertebrates and plants over evolutionary time, such that now neither could exist without the other dictates a common ground for their protection. Unfortunately in Europe, this is not yet the case. Better communication and coordination with the other major interest groups and the resulting combined effort could greatly enhance the success of conservation of invertebrates and also greatly enhance their public acceptance. Perhaps this could be most simply achieved by using the infrastructure of the Council of Europe and the Bern Convention that is already in place to encourage and support contact and coordination between the various European Groups of Experts. Such a link has already been suggested between the Invertebrate Group of Experts and the recently formed Group of Experts on conservation and climate change, as discussed at the last meeting of the Invertebrates Group in 2007. At that meeting there was also much discussion about how to take the Invertebrate Strategy forwards, but despite many words, little has happened since. It is clear that a strong and focussed marketing initiative will still be essential to further awaken public interest and to gain the attention of politicians.

This brings me back to that writing of Cyrille de Klemm that I cited earlier. He places the credit for the resounding success of nature conservation in Europe as he envisaged with a turn in public opinion: '*After the crisis, the public took up the cause of biological diversity and natural habitats with increasing determination…….. Democracy did the rest*'.

It will still take time, considerably longer than de Klemm´s forecast, but it may be hoped that public support will indeed rally, sufficiently to bring invertebrate conservation in Europe closer to the Vision defined in the Invertebrate Strategy as '*A world in which invertebrate animals are valued and conserved, in parallel with all other groups of organisms, now and in the future*'.

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Chapter 15
Development and Future of Insect Conservation in Japan

Minoru Ishii and Yasuhiro Nakamura

15.1 Nature and Insect Fauna of Japan

Japan is located at the eastern edge of the Eurasian Continent, and is an island nation composed of four large islands—Hokkaido, Honshu, Shikoku, and Kyushu—and a large number of small islands. Although the Japanese Archipelago is relatively small (with the total area of land approximately 380,000 km^2), the climate ranges from subtropical to the Frigid Zone, with a temperate zone that has four distinct seasons at the centre; the Japanese Archipelago is approximately 3,000 km from north to south, extending from latitude about 45° N to about 20° N. Moreover, Japan is a volcanic country, and mountain ranges run in all directions on each island. There are numerous mountains with various heights including the highest mountain, Mt. Fuji (3,776 m).

Regarding vegetation, Japan is a forest country in that about two thirds of the land area is occupied by forests, which have developed with the support of abundant precipitation (1,000–3,000 mm/year). The vegetated areas are largely temperate deciduous broad-leaved forests in east Japan and evergreen broad-leaved forests in west Japan, but boreal coniferous forests occur in Hokkaido and on the high mountains in Honshu. Mangrove forests are present along the coastline in the Southwest Islands, and boreal forests are observed in the high mountains of Hokkaido. However, the proportion of artificial forest is as high as 40%, and primary forest is just below 20%.

The location, geographical features, history, climate, and vegetation of the Japanese Archipelago support a rich insect fauna. Up to the present, approximately 32,000 species of insects have been recorded in Japan (Table 15.1; Ishii et al.

M. Ishii (✉)
Entomological Laboratory, Graduate School of Life and Environmental Sciences,
Osaka Prefecture University, Sakai, Osaka 599-8531, Japan
e-mail: ishii_m@envi.osakafu-u.ac.jp

Y. Nakamura
Japan Butterfly Conservation Society, Ohi 1-36-1-301, Shinagawa, Tokyo 140-0014, Japan

T.R. New (ed.), *Insect Conservation: Past, Present and Prospects*,
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1996–1998), but this number is believed to reach about 100,000 following the development of surveys and studies. As Japan is a forest country, the insect fauna in Japan have characteristics of abundant forest species (e.g. Morimoto 2006). In addition, because the Japanese Archipelago has been formed through geo-historical processes, having previously experienced connection with and separation from the Eurasian Continent, the level of endemic species and subspecies is remarkable. In addition, the Ogasawara Islands, one group of 'oceanic islands' that have never been connected to continental land, have a large proportion of endemic species (e.g. Habu 1986; Kishimoto 2010).

From a biogeographical point of view, the mainland of Japan is located at the eastern edge of the Palearctic Region, and the Southwest Islands are located at the northeastern edge of the Oriental Region. However, it should be noted that the insects in Japan include a large number of species distributed around the Japan Sea and species distributed from south China, and across north Indochina to the Himalayas. Among the insects in Japan, the species whose distribution is limited to areas in east Asia, known as the 'Sino-Japanese region', are believed to be those with the oldest origin (Hiura 1973).

15.2 Development of Human Society and Change of Nature in Japan

Humans are believed to have settled in the Japanese Archipelago several tens of thousands of years ago in the Pleistocene. About 10,000 years ago (early Jomon period), i.e. when the fourth glacial stage (Ulm glacial stage) had ended and temperatures began to once again rise, the ancestors of the Japanese are believed to have been half settled and had started semi-domestication with wet-paddy rice cultivation. During this period, the ancestors harvested the fruits from deciduous broad-leaved forests such as the Japanese beech, *Fagus crenata*, and the mongolian oak, *Quercus mongolica*, in east Japan, as well as from evergreen broad-leaved forests in which evergreen oaks and *Castanopsis* trees dominated in west Japan, and led a life in harmony with and almost completely dependent on the forest (Sasaki 1993).

Thereafter, when the culture of rice cultivation was introduced in the late Jomon period or the early Yayoi period (about 3,000 years ago), a settled life in lowland Japan had commenced. During this period, it is believed that west Japan was covered with deep laurel forest and impacts on the ancestral forests became gradually stronger owing to factors such as wet-paddy rice cultivation, the introduction of iron hardware, and population increase. However, aided by a warm climate with high levels of precipitation, secondary forests consisting of the Japanese red pine, *Pinus densiflora*, and the Konara oak, *Quercus serrata*, were developed on the hills behind villages. These secondary forests, composed of coppice, continuously provided fuel, fertiliser, food, and wood until the 1950s, as well as being habitats for various insects. Moreover, after the introduction of wet-paddy rice cultivation, the river floodplain became a paddy field zone, and it is thought that the aquatic insects that inhabited natural wetlands have survived by using rice farming water systems as refuges (e.g. Moriyama 1998).

History has shown that in Japan, where natural environments and insect fauna are rich, the ancestors had lived in connection with insects. Farmers felt the impact of various insect pests. Plant hoppers, in particular, frequently caused extensive damage to food resources, leading to famine during the Edo period (1603–1867). The familiar cultural relationship between the Japanese and insects can be found in pictures and literature, such as folktales, *Waka* poems and *Haiku* poetry. There has been a culture of insect-listening parties from old times, and insect sellers selling crickets were present in the Edo period.

Japan had closed the country during the Edo period but reopened the country in the early Meiji period (1868–1912). In 1914, a plant protection station was established in response to the large abundance of alien pest species brought into the country through imported useful plants (e.g. Kiritani 1999). During the Meiji period, the population of Japan increased rapidly from approximately 35 million to exceed 50 million, and since then, the population has steadily increased to reach the current population level of approximately 120 million.

The word ‘Shizen’, which represents ‘Nature’ in Japan is believed to be a new word born during the Meiji period (Murasugi 1998). The view of nature by the Japanese, who are influenced by Buddhist culture, is based on the ‘samsara’ way of thinking, and the Japanese believed that the soul that returned to the other side after death would reincarnate many times on this side, through rebirth as other living organisms. For example, the Japanese dictionaries in the 1950s stated that nature represents all matter in the world, such as mountains, rivers, plants, and animals, including humans, suggesting that humans were thought to be a part of nature. However, the dictionaries produced later, in the 1990s, show a shift in the view of nature, stating ‘nature is everything that surrounds human society and opposes humans in some sense, such as astronomical objects, mountains, rivers, plants, and animals’. This perspective seems to be influenced by a Western view of nature (Murasugi 1998).

After the end of World War II, reconstruction and economic development began in Japan. In particular, the period from 1955 to 1973 is referred to as the high economic growth period, and the Gross National Product (GNP) reached the second position among capitalist countries in 1968. The Tokyo Olympics were held in 1964, and the constructions of the Shinkansen bullet train and expressway networks were initiated during this period. The 1970s were a stable growth period of economy, and further development advanced throughout the nation, modeled on the ‘Plan for Remodeling the Japanese Archipelago’ act released in 1972. It was around this time when large-scale collective housings were constructed in various parts of the country. The period from the late 1980s to early 1990s was the period of ‘bubble boom’. Throughout these periods of post-war economic development, the city areas have expanded and resorts have been developed in various regions.

A decline in populations of butterflies in the urban area is a typical outcome of this situation. The decline of butterfly fauna due to urbanisation has been investigated well in large cities such as Tokyo and Osaka. For example, in the early 1900s, more than 60 species of butterfly inhabited Osaka city. This number decreased to approximately 40 by the 1950s, and only around 30 resident species can be found after the 1960s (e.g. Hiura 1973). Hiura (1973) pointed out that the butterfly declines caused by urbanisation are of woodland, sedentary, univoltine, and native plant feeding species, and, conversely, the butterflies that remain in the urban green space are grassland, migratory, multivoltine, cultivated or alien grass feeding species.

As a social movement during this period, the Ozegahara dam plan by the Tokyo Electric Power Company emerged in 1948, and this set off the foundation of the Nature Conservation Society of Japan (NACSJ) in 1951, which is the first private nature conservation group in Japan (Yoshida 2007). During the 1970s, environmental problems such as environmental pollution, which increased successively in the 1960s, led to the establishment of the Environmental Agency of Japan (EAJ) in 1971 (thereafter, promoted to the Ministry of the Environment, MOE, in 2000). It was this year when the World Wide Fund for Nature Japan (WWFJ) was established.

15.3 Status Quo of Japanese Insects from the Perspective of Red Lists

The first Red Data Book (RDB) in Japan is the plant edition that was issued by the NACSJ and WWFJ in 1989. The book listed as many as 895 species (including subspecies, as in other such listings referred to below) including 35 extinct species and 824 endangered species, as well as listing herbaceous plants in *Satoyama*, the traditional rural landscape of Japan, which has been familiar to the Japanese since olden times. The animal edition was issued by the EAJ in 1991 and listed 631 species, including 22 extinct and 215 endangered species (EAJ 1991a, b). This book also referred to the names of familiar animals in *Satoyama*.

The simple sum of the number of the animal and plant species listed in these first RDBs in Japan is 1,526 species, of which 57 were extinct species. At the time of publication, the large number of plant and animal species received great attention, both for the initial species abundance and the later decline of species found relatively commonly in the landscape of *Satoyama*. Following the fuel and fertiliser revolution that started in the 1950s, and the high economic growth period in the 1960s, people came to a sudden realisation that the familiar wildlife was disappearing, together with the once familiar landscape of *Satoyama*. During this period when the Japanese began to feel the benefits of convenient and rich life style, the state of the nature of *Satoyama*, which can be regarded as the original landscape of Japan, was declining.

Following this period, the number of species listed on the Red List (RL) by the MOE have been increasing with every revision, and the animal species in *Satoyama* have been added in sequence (Fig. 15.1). As a result, the third and most recent list by the MOE (2006), lists as many as 4,828 species of animals and plants, including

120 extinct species. The species listed on the RL in Japan (red species) have increased by more than threefold within the 20 years after the release of the first edition.

A significant factor for this increase in the species listed on the RL by the MOE is probably related to the progress in understanding wildlife ecology and habitat needs, alongside the RL preparation at local government and academic society levels. However, given the increase in the number of listed vertebrate and butterfly species, for which surveys have been relatively high in accuracy since the beginning of publication, it is plausible to suggest that the environment in Japan has been slowly changing.

Regarding insects, 212 species were listed in the first edition of the RDB by the EAJ (the first list); 392 species were listed in the second list released in 2000; and 566 species were listed in the third list in 2007, displaying a 2.7-fold increase in the number of species listed on the RL just 16 years after the issue of the first edition (Table 15.1; Fig. 15.1). Moreover, the extinct species in the first and second lists were two species of beetles inhabiting caves, whilst a wetland beetle was newly added to the third list.

Distribution analysis of the species listed on the second list shows that about two thirds of the species are endemic to Japan (Fig. 15.2; Ishii 2003). In particular, it should be noted that about one quarter of the listed species are those endemic to islands such as Nansei, Ogasawara, and Tsushima Islands. Moreover, the listed non-endemic species that, approximately, compose the remaining one third are mostly constituents of the 'Sino-Japanese region'. The fact that the Sino-Japanese species, the majority of which are temperate zone inhabitants, comprise as much as 90% of the insect red species, demonstrates clearly that the Japanese environment has changed.

Habitat examination of the species listed on the second list shows that the highest numbers of species (approximately 40%) inhabit woodlands, including coppice, followed by species inhabiting lentic water environments, including ponds, wetlands, and wet paddy fields (18%), and species inhabiting dry or wet grassland (16%). The above comprise three quarters of the entire species list (Fig. 15.2; Ishii 2003). Generally, most of these species are found in the altered environment of *Satoyama*. The remaining quarter are species inhabiting rivers, tidal zones and river mouths at the seashore, sand and grassland at the shores of seas and rivers, caves, underground and groundwater, and high mountains.

Two endemic beetle species that are currently assigned to 'extinct species' among Japanese insects inhabit the shallow ground layer and caves, and are under threat of submersion by dam construction, and disappearance and desiccation of habitat by limestone mining and public engineering works. Seven species from this group were added to the third list as endangered species.

Woodland species in the primary forest and coppice are included on the red list, but species from each environment differ from each other in endangered status (see below for coppice). The preservation of the state of the remaining evergreen broad-leafed forests is essential for the habitation by the red species in the primary forest, such as the lycaenid, *Shijimia moorei,* and the long-armed scarabaeoid beetle, *Cheirotonus jambar*. The critical endangering factors include

Table 15.1 Numbers of Extinct (EX), Critically endangered (CR), Endangered (EN), Nearly threatened (NT) and Data deficient (DD) taxa (species and subspecies), and Local populaions of each order of insects listed in the third Red List published by the Ministry of Environment, Japan in 2007

Order	EX		CR		EN		NT		DD		LP		Total no. taxa[a]		Total no. of species		No. known species[b]	% of red species to known species	
Ephemeroptera							2	(2)	3	(2)			5	(4)	5	(4)	170	2.9	(2.4)
Odonata			11	(10)	10	(10)	26	(18)			1	(1)	48	(39)	46	(37)	190	24.2	(19.5)
Plecoptera					1	(1)	1	(1)	1	(1)			3	(3)	3	(3)	170	1.8	(1.8)
Grylloblattodea			1	(1)					1	(0)			2	(1)	2	(1)	6	33.3	(16.7)
Orthoptera							4	(2)	2	(2)			6	(4)	6	(4)	390	1.5	(1.0)
Blattaria									6	(1)			6	(1)	4	(1)	52	7.7	(1.9)
Dermaptera									1	(1)			1	(1)	1	(1)	20	5.0	(5.0)
Psocoptera									1				1	(0)	1	(0)	92	1.1	(0)
Hemiptera			4	(6)	22	(16)	41	(38)	20	(13)	1	(1)	88	(74)	88	(74)	2,920	3.0	(2.5)
Neuroptera									2	(1)			2	(1)	2	(1)	150	1.3	(0.7)
Coleoptera	3	(2)	64	(27)	53	(20)	53	(37)	38	(23)			211	(109)	207	(109)	10,600	2.0	(1.0)
Diptera			5	(1)	4	(4)	1	(1)	14	(12)			24	(18)	24	(18)	5,300	0.5	(0.3)
Hymenoptera			3		10		18	(10)	24	(25)		(1)	55	(36)	55	(36)	4,500	1.2	(0.8)
Mecoptera									6	(4)			6	(4)	6	(4)	45	13.3	(8.9)
Trichoptera					2	(1)	4	(5)	1	(1)			7	(7)	7	(7)	320	2.2	(2.2)
Lepidoptera			22	(18)	27	(24)	50	(47)	2	(1)			101	(90)	79	(74)	6,250	1.3	(1.2)
Others													0	(0)	0	(0)	996	0	(0)
Total	3	(2)	110	(63)	129	(76)	200	(161)	122	(87)	2	(3)	566	(392)	536	(374)	32,171	1.7	1.2

Numerals in parentheses indicate data from the second Red List released in 2000 (Ishii 2005)

[a]Including subspecies and local populations

[b]Based on Ishii et al. (1996–1998)

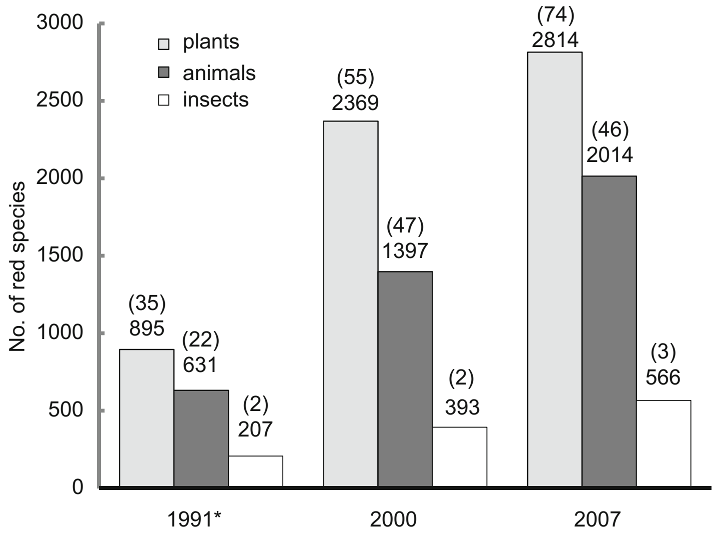

Fig. 15.1 The number of plant, animal and insect species (including subspecies) listed in the first (1991), second (2000) and third (2007) Red Lists published by the Ministry of Environment, Japan. Numerals in parentheses indicate the number of extinct species. *The number of red plant species in 1991 is based on the Red List published by NACSJ and WWFJ (1989)

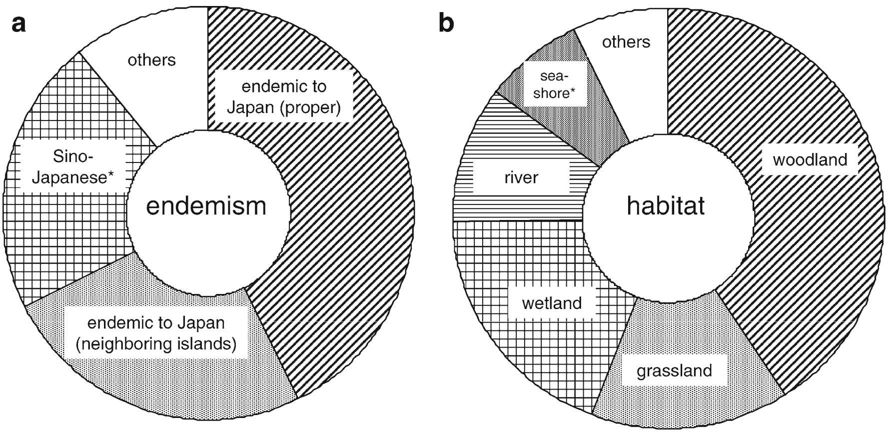

Fig. 15.2 Percentage of species endemic to Japan (**a**) and habitats (**b**) in a total of 393 insect species (including subspecies) listed in the second Red List released by the Ministry of Environment, Japan in 2000 (Ishii 2005). *"Sino-Japanese" excludes species endemic to Japan, and "Seashore" includes the mouth of rivers

deforestation associated with development, forest road construction, and plantation forestry.

In river environments, the insects that depend on the reed field from the middle sections to the river mouth are under threat. Around the river mouth, in particular, coastal tiger beetles and a damselfly, *Mortonagrion hirosei*, are threatened by the disappearance of reed fields and the degradation of water quality due to bank protection works, landfill, and facility construction. Moreover, gravel ground on the riverbed is not present in the river running through cities, and the stony riverbed grasshopper, *Eusphingonothus japonicus*, is listed on the RDB by the local government in various regions.

The sandy soil at seashores and the river mouth is also in critical condition because of the disappearance of natural seashore due to bank protection, a decrease in the amount of sand, water quality pollution, human access for sea bathing and sightseeing, and the entry of motorcars and motorbikes (Gohkon 2010). As a result, the insects that depend on this environment are also declining. Specifically, five out of six species of Japanese coastal tiger beetles, which inhabit the sandy soil at seashore and the river mouth, are listed in the RL in a severe state (Satoh 2008).

In water areas such as the river mouth and cove, marine skaters are declining because of the decrease in the natural state of the river mouth and seashore, as well as water quality pollution.

Generally, approximately half of the red species – not only insects but also of other wildlife – are believed to be observed in *Satoyama*, which includes coppice, rice cultivation water systems, and meadow. *Satoyama* is one of the ‘biodiversity hotspots’ in Japan, and thus the collapse of the surrounding environment is a major factor responsible for the decline in biodiversity in Japan (NACSJ 2005; Ishii 2003, 2009).

The coppice in Kanto and Kansai regions is mainly composed of the Japanese red pine and deciduous trees such as *Quercus serrata* and *Q. acutissima*, and has been maintained by regular thinning, weeding, and raking of fallen leaves by farmers as firewood forest or farm forest. However, the fuel and fertiliser revolution from the 1950s to 1960s depreciated the value of *Satoyama* coppice, and a large number of familiar insects declined in abundance due to destruction and abandonment of this habitat.

Grass was formerly an important resource as fodder for cows and horses, fertiliser, and as the materials for roofing and agriculture. The landscape of farming villages is composed of various types of grass fields, such as hayfield and meadow. However, the value of these grass fields has also degraded and grassland insects have declined because of succession, through invasion of the dwarf bamboo, *Pleioblastus chino*, and alien herbaceous plants, and conversion to forest. As a result, a large number of butterfly species inhabiting lawn fields, meadow, and silver grass fields have become endangered.

The rice cultivation water system, consisting of paddy fields, ditches, and irrigation ponds, used to be the primary environment in the landscape of *Satoyama*. However, the habitats of insects in this system have deteriorated because of farm land consolidation, associated pipeline construction in place of ditches, shifts from paddy fields to well-drained rice fields, concrete bank protection of irrigation ponds and ditches, water quality degradation due to inflow of agricultural chemicals and domestic wastewater, and abandonment of tillage (e.g. Ichikawa 2009, 2010). Furthermore, many wetlands and ponds have been land-filled due to development in various places. Under these situations, aquatic insects that were once commonly observed in nearby rustic environments are rapidly declining. In *Satoyama,* the endemic red dragonfly, *Sympetrum frequens*, is reported to be rapidly declining across the country in recent times due to the use of insecticides (Ueda 2007).

In general, the island ecosystems are relatively vulnerable and occur only on a small scale. The insects in the Ogasawara Islands, where the proportion of endemic species is as high as about 30%, are dramatically declining due to the construction of dams and various facilities, aerial spraying of insecticides, an increase in wild goats, and predation by the Carolina anole, *Anolis carolinensis*, which has been introduced unintentionally and has increased in numbers to a population of several million (e.g. Karube 2006; Kishimoto 2010). Invasive species effects are more widespread.

The Largemouth bass, *Micropterus salmoides*, which has spread throughout the water bodies of Japan, has been found to feed not only on aquatic insects but also on adult dragonflies (Karube 2005). The Louisiana crawfish, *Procambarus clarkia,* destroys vegetation in the water bodies and threatens aquatic insects such as diving beetles through competition for food (Nishihara 2009; Nishihara and Karube 2009).

The Argentine ant, *Linepithema humile*, was discovered in 1993 and distribution patterns show population expansion in western Japan (Sugiyama 2000; Terayama 2002, 2005; Ito 2006). This ant expels domestic ants, as well as exhibiting strong aggressive behaviour toward small animals, such as other insects. Moreover, the tropical fire ant, *Solenopsis geminata*, has been found in subtropical islands, and is the most dominant ant species on Iwo Island (Terayama 2005).

Mass introductions of foreign insects have also begun to inflict harm on domestic ecosystems. Since 1999, reduced import regulations by the Plant Protection Act have seen an increase in foreign stag beetles and rhinoceros beetles into Japan. As a result, foreign beetles have become more prevalent (Araya 2005) and foreign mitochondrial DNA has been detected in Japanese stag beetles collected outdoors (Goka and Kojima 2003). In addition, the European bumblebee, *Bombus terrestris*, which is imported from Europe for the pollination of facility-culture tomato on a scale of several tens of thousands of colonies per year, has settled outdoors in Hokkaido and has become the dominant species that oppresses domestic bumblebees (Yokoyama and Nakajima 2005; Yokoyama 2010).

The settlement and expansion in distribution of alien butterflies smuggled and released into the country has also become a serious issue. The papilionid, *Sericinus montela*, which was first sighted in Tokyo in 1978 and has now spread from Kanto, Kansai, and Chugoku areas to a part of the Kyushu area, threatens the existence of the native papilionid, *Atrophaneura alcinous*, which shares hostplant species with *S. montela* (Sakuratani and Kanno 2003; Inoue and Kon 2006). The distribution of a continental subspecies of the nymphalid, *Hestina assimilis assimilis*, which was first sighted in the Kanagawa prefecture in 1998, is expanding rapidly in the south Kanto district (Iwano 2005, 2010). The distribution of *H. a. assimilis* is of concern because this species shares host plants with the native species, *Hestina japonica* and

Sasakia charonda, as well as invading Amami Oshima Island and the surrounding islands where the Japanese subspecies, *H. a. shirakii,* is distributed.

The introduction of alien populations or subspecies of butterflies and beetles within Japan cannot be ignored. For example, the endangered univoltine papilionid, *Luehdorfia japonica*, which inhabits Ishizare Mountain, has been designated as a protected species in the Kanagawa prefecture, but the release of individuals from other populations has recently resulted in genetic disturbance (Hara 1996; Matsumoto 2004; Takakuwa 2004). Furthermore, since its introduction, there has been a prolific increase in the mainland Japanese horned beetle into Hokkaido, as well as into Okinawa Island, where a subspecies of the Japanese rhinoceros beetle, *Allomyrina dichotoma takarai*, is distributed (Araya 2002; Kohama 2002). In the ‘Firefly countryside creation activities’ which are conducted across the country, there are an increasing number of cases in which populations of the Genji firefly, *Luciola cruciata,* from other areas are released without careful consideration of the genetic difference (Suzuki et al. 2002; Ohba 2006).

Although not truly alien species, the damage to agriculture and destruction of forest floor vegetation by wild beasts such as deer and boar is recently becoming more prevalent in various areas (Yamada 2000, 2005). In Nikko in the Tochigi prefecture, the dwarf bamboo community on the forest floor is withered and dead due to feeding damage by deer. Butterflies that depend on the dwarf bamboo community have almost disappeared in some areas (Hasegawa 2009). One of the principal factors responsible for such an increase in deer destruction has been the reduced death rate of deer over the winter months as winters become increasingly warmer (Yorimitsu 2011).

While global warming allows rapid expansion in the distribution of southern species, a changing climate can also limit the distribution and subsequently increase extinction rates of northern species such as the American checkerspot, *Euphydryas editha* (Parmesan 1996). Tanikawa and Ishii (2010) analysed the climatic conditions of the habitat of *L. japonica* and pointed out the possibility that a warming tendency in recent years would reduce the distribution area of this species, owing to a large number of locations undergoing transitions to low temperatures below 5°C in winter.

15.4 Development of Government Measures for Insect Conservation in Japan

After the country was opened in the Meiji period, the main policies behind nature conservation by the nation and local government until the 1960s were the Act on Protection of Cultural Properties (APCP, established in 1950; the predecessor is the Law for the Protection of Historic Sites, Places of Scenic Beauty, and Natural Monuments, established in 1919), the Natural Park Act (NPA, established in 1957; the predecessor is the National Park Act, established in 1931), and the Wildlife Protection and Proper Hunting Act (WPPHA, established in 1963; the predecessor is the Rule for Beasts and Birds Hunting, established in 1873). Species of insects, including butterflies and fireflies, and their habitats, have been listed as protected species under the APCP; their habitats have also been listed as special protection zones under the NPA and as wildlife protection areas under the WPPHA. However, the preservation as protected species without suitable monitoring and management of habitat often resulted in increasing extinction rates of target species. For example, the Tailless Bush Blue, *Panchala ganesa loomosi*, in Mt. Kasuga in the Nara prefecture, became extinct due to pesticide applications following the declaration of their habitat of evergreen broad-leaved forests as a national natural monument in 1932. Because the species targeted for protection are often limited to well-known species, such as *L. japonica* and *L. cruciata*, while species under great threat are ignored, the system of enlisting protected species remains biased and thus lacks effectiveness in the conservation of biodiversity.

The Nature Conservation Law (NCL), established in 1972 for the purpose of comprehensive preservation of natural environments, generated the establishment of the Nature Conservation Council. Based on the NCL, the Basic Policies for Nature Conservation were established, followed by the designation of areas described as superior natural environments as Nature Conservation Areas. The National Survey on the Natural Environment (NSNE), which is conducted at 5-year intervals nationwide, has commenced. The NSNE on insects has been conducted since the third survey in 1984: dragonflies, cicadas, aquatic hemipterans, butterflies, a portion of moth species, tiger beetles, stag beetles, diving beetles, and flower longhorn beetles are the main targets of the survey.

Following the Earth Summit in 1992, the approach toward conservation based on the Convention on Biological Diversity (CBD) has become an increasing trend in Japan. The Law for the Conservation of Endangered Species of Wild Fauna and Flora (LCES) established in 1993, selects National Endangered Species (NES) from the species listed on the RL, and enforces monitoring and preservation of habitats. As for insects, 15 species including the dragonfly *Libellula angelina*, the lycaenid *Shijimia moorei*, and the scarabaeoid *Cheirotonus jambar,* have been selected. The trend associated with the preparation of the RL and the establishment of the regulations based on the LCES is becoming popular among local governments.

In 1995, the Japanese government established the National Biodiversity Strategy of Japan (NBSJ) based on the CBD. Based on the second strategy in 2002, three crises exist as the crisis factors for the biodiversity of Japan: (1) the crisis due to human activities and development; (2) the crisis due to the reduction of human activities in *Satoyama*; and (3) the crisis due to alien species and chemicals that have been brought in by humans. In particular, the conservation of the secondary natural areas in *Satoyama*, which has been recognised as important in the conservation of biodiversity and is comprised of several policies following the second strategy, has begun.

Among them is the revision of the NPA in 2002, with the addition of securing biodiversity as a policy for natural parks. Based on the revised NPA, some endangered animals were selected based on regulations of their capture in designated zones of the National Parks and Quasi-National Parks. In addition, provisional measures such as monitoring inhabitation behaviour and maintenance/restoration of habitats would be conducted. Regarding insects, three species of butterflies in *Satoyama* were selected.

The Nature Restoration Act (NRA) was also established in 2002 with the purpose of recovering the natural environment that had deteriorated in the past. The NRA established a system in which various local constituents such as government, residents, and specialists participate, and the preservation, regeneration, and creation of natural environments were conducted. In *Satoyama*, nature regeneration projects have commenced in the grasslands around Mt. Aso in the Kyushu district and in the coppice of Musashino in the Kanto district. After the revision of the APCP in 2005, cultural landscapes such as terraced rice paddies and coppice, which have been formed using local nature and culture, were listed as cultural properties, establishing a system for sustained preservation and application.

The Project of Comprehensive Ecosystem Monitoring System (Monitoring Sites 1,000) commenced operation in 2003. In this project, about 1,000 places with significant ecosystems in Japan, such as high mountains, forests, *Satoyama*, lakes and marshes, sand beaches, tidal flats, and coral reefs were selected for continuous monitoring for 100 years. The information is documented in the local conservation policies. The NACSJ is responsible for the *Satoyama* category, and citizen volunteers conducted surveys of indicator species such as butterflies, fireflies, and frogs, in addition to plants, birds, mammals, and water quality assessments at approximately 200 sites of *Satoyama* across the country. The surveys of butterflies, using a transect count method, have currently been conducted at approximately 40 sites, with documented evidence of northward invasion in tropical/subtropical butterflies. Alpine butterflies and carabids are targeted in surveys as indicator species for the high mountain category and forest category, respectively.

The Invasive Alien Species Act (IASA), established in 2005, concluded that the alien species that inflict significant damage to domestic ecosystems, agriculture, the forestry and fisheries industries, and human health would be categorised as specified invasive alien species. In addition, regulations behind raising, cultivating, keeping, transporting, releasing, and importing the species into the country were enforced, including necessary control. Eight species of insect including the Argentine ant, the tropical fire ant, and the European bumblebee are currently listed as specified invasive alien species. Based on this act, the European bumblebee that has become established in Hokkaido and the Argentine ant that has invaded the Port of Yokohama are being eliminated. In addition, the Carolina anole which is a threat to endemic insects in the Ogasawara Islands, is also being eliminated. However, alien stag beetles and the Chinese subspecies of the nymphalid, *H. a. assimilis*, both of which cause genetic disturbance in native subspecies, and the Louisiana crawfish which is a threat to aquatic insects, are not at present designated as specified invasive alien species, necessitating future, ongoing support for the IASA. Moreover, there are currently no measures in place to resolve the issues surrounding the Genji firefly and the Japanese rhinoceros beetle, which are introduced into other areas of Japan, causing genetic disturbance in the local insect populations.

There has been slow progress behind the action of ex-situ preservation in Japan. In 2009, the ‘Basic Policies on the Ex-situ Preservation of Endangered Wild Animal and Plant Species' was established by the MOE. Model projects for ex-situ preservation are currently underway with an overall aim of reducing the extinction of species and maintaining genetic diversity. Knowledge on the techniques for successive breeding and dissemination of domestic insects has been gradually increased, as well as on genetic diversity, specifically on grassland butterflies that are under threat of extinction, such as the Grass Blue, *Zizina emelina*.

15.5 Activities of Nongovernmental Bodies for Insect Conservation

In addition to the efforts by the government, academic societies such as the Entomological Society of Japan (ESJ), the Lepidopterological Society of Japan (LSJ), the Japanese Society for Odonatology (JSO), and the Japan Coleopterological Society (JCS) have contributed information and educated society on the current conservation situation of insects and their habitats. These societies have also submitted requests to the government for the preservation of habitats. The LSJ established a nature conservation committee in 1965, and issued a report 'Decline and Conservation of butterflies in Japan' volumes 1–6 (1989–2009), which includes a Red List of each prefecture. The LSJ also held seminars on nature conservation for educational purposes. Furthermore, the LSJ, in collaboration with local governments and the public, set up a section for the conservation of habitats of endangered butterfly species such as the checkerspot, *Melitaea protomedia* (Nanba 2009).

The ESJ also set up a nature conservation committee in 1966, and has since held public symposiums and issued 'Important areas for the conservation of insect biodiversity' volumes 1–3 (1999–2002). Specifically, the 'Request toward early establishment of the Act for control of alien species associated with the import of foreign insects', which was submitted to the MOE together with the CS and the Japanese Society of Systematic Entomology in 2002, has given momentum to the establishment of the IASA. The nature conservation committee of the JSO also set up a section that targets species such as *Libellula angelina* and *Mortonagrion hirosei* that have been assigned to a high rank on RL by the MOE, as well as endemic species of the Ogasawara and Okinawa Islands, and develops activities focused on their conservation.

As environmental degradation and the associated decline of wildlife in *Satoyama* becomes more prevalent, there has also been an increase in support by civic groups towards the conservation of the surrounding environment throughout various locations in Japan. Most civic groups hold nature observation walks, conduct surveys, and maintain the natural state of grassland and woods, but few groups are associated with the conservation of habitats of insects such as butterflies, dragonflies, and fireflies. In 'Mt. Mikusa Coppice for Zephyrus' in the northern part of the Osaka prefecture, the Osaka Green Trust, in 1992, entrusted a coppice of approximately 14 ha inhabited by ten species of Thecline butterflies (Ishii et al. 1995; Hirowatari et al. 1996; Ishii 1996). Further, the vegetation in this area is managed through a collaborative effort between the public and specialists. The members of the LSJ and university researchers conduct monitoring surveys on butterflies, the results of which are reflected in the vegetation management (Ishii et al. 2003; Nishinaka and Ishii 2006, 2007).

Action for conservation of butterflies and their habitats has increased across various locations since the 1980s, but the target species were limited to relatively well-known butterflies, such as *Luehdorfia* species, the lycaenid *Coreana raphaelis*, and the Japanese Emperor, *Sasakia charonda*. Further, with each new RL revision by the MOE, the number of listed species has increased and the situation surrounding the number of endangered species has become progressively worse each year. In response, the Japan Butterfly Conservation Network (currently the Japan Butterfly Conservation Society) was founded in 2004 as a society that promotes the practical conservation of endangered butterflies (Nakamura 2011). Efforts for the conservation of butterflies are currently conducted across various locations, with the efforts from each body, such as government, researchers, and civic groups across the country adding up to more than 30 (Nakamura 2011). In addition, some areas under effective management are producing steady results, such as an increase in the population of the subject species.

For example, the 'Conservation Society of *Scotosia* Checkerspot Butterfly' which is a local civic group in the Hiroshima prefecture, has requested landowners to avoid further destruction of the environment that serves as a habitat for this butterfly. This society also conserves the habitat by mowing wet grassland areas, conducting observation walks for the public, and running environmental educational programmes at local elementary schools (Iwami et al. 2006). Through these efforts by civic groups to maintain and restore these habitats, the checkerspot, *Melitaea scotosia*, in its last habitat in Japan, has been sustained.

The target species of dragonfly for conservation are rarely specified. The conservation of ponds and surrounding vegetation, and the construction of 'Dragonfly Park' using fallow rice fields, are undertaken across various locations. In Iwata city of the Shizuoka prefecture, for instance, the natural environment of the Okegaya pond which is inhabited by 65 species of dragonfly, such as *L. angelina*, is conserved as a natural environment conservation area of the prefecture through collaboration with civic groups, landowners, residents' associations, and the government (Fukui 2010). Further, downstream to the Shimanto river in the Kochi prefecture, a civic group constructed a dragonfly natural park (known as 'Dragonfly Kingdom') using abandoned rice fields in the valley, and with financial assistance from the WWFJ and the government (Sugimura and Ichii 1990; Sugimura 2005). Because the habitat of the endangered damselfly *M. hirosei* is at risk of deterioration due to construction of sewage treatment plants at the river mouth area of the Miyagawa River in the Mie prefecture, brackish water was introduced to the neighbouring area as a mitigation measure and a reed community was created (Watanabe et al. 2008).

The conservation activities for giant water bugs and diving beetles are widespread (Nishihara 2010). In the Hyogo prefecture, the 'Giant Water Bug Biotope' was developed in 1999 using abandoned rice fields in the suburb of Himeji city; the site has since been used by local NGOs to conduct environmental management, for observation tours for elementary schools, and for conducting surveys. This biotope is currently the centre for environmental study of Himeji city, and a large number of aquatic insects including other aquatic hemipterans and diving beetles can be observed (Ichikawa 2009, 2010).

Of the fireflies, the Heike firefly, *Luciola lateralis*, and the Small firefly, *Hotaria parvula,* as well as the Genji firefly have been, since early days of conservation awareness, the main subjects in conservation action, in which governments are actively involved across various locations. In 1924 at Moriyama in the Shiga prefecture and in 1925 at Tatsuno in the Nagano prefecture, the habitat of the Genji firefly was designated as a natural monument of the country and the prefecture, respectively. Other local governments across the country followed with similar action thereafter (note, however, that the designation of the Moriyama site was revoked following extinction of the population). For the river running through the residential zone in Yokosuka city, the Genji firefly, was recovered by altering the flow alongside the forest, shutting down the inflow from various drainage points, and re-forming the concrete covered bank and river floor to a natural state so that plants could grow (Ohba 1996). There was also a case of mowing and changing the lighting direction at the nearby expressway in an effort to sustain conservation of the Small firefly, that inhabits the outer moat of Nagoya castle.

15.6 Problems and Future of Insect Conservation in Japan

As previously mentioned, conservation efforts for insects are expanding, but the number of endangered species is also steadily increasing. The NBSJ proposes to 'maintain and recover the population and habitat of the presently endangered species along with avoiding new occurrence of the fear of extinction of the species inhabiting this country.' However, the insects that are selected as NES based on the aforementioned LCES are few, with only 15 species so designated. On the other hand, the population of the endangered butterfly species that at present require urgent attention in conservation is estimated to be as many as 160. Based on current policies, large-scale conservation action is required in order to reach a suitable and effective level of conservation of insect biodiversity.

Priorities for the future conservation of insects can be best summarised in two ways: (1) to prevent the extinction of species that are already extremely low in numbers; and (2) to take conservation measures at the landscape level to include animals and plants that are considered less under threat. The former is exemplified by certain conservation actions that have targeted butterflies, dragonflies, fireflies, diving beetles, and the giant water bugs, as mentioned above. However, many cases depend on civic groups, and ideal measures are actually not implemented to a satisfactory extent. Regarding endangered species, generous conservation measures in which species and habitat are specified based on the LCES, the NPA, and other relevant regulations are increasingly expected.

For the latter, which are relatively large in population numbers, alternative methods of conserving the whole habitat at the landscape level are required. In the *Satoyama* area where endangered insects are more predominant, there is a need for further promotion of agriculture and silviculture with lower impacts on biodiversity, and a greater focus on the construction of social and economic systems that restore and maintain the environment. Fortunately, the conservation of *Satoyama,* the regeneration of ecosystems, and the establishment of local strategies for biodiversity are included in the Basic Law on Biological Diversity, which was established in 2008. Regarding the conservation of *Satoyama*, it is explicitly stated that 'the nation is to construct a system for the sustained conservation of the relevant areas according to the natural and social conditions of local areas, and to take any other required measures for the purpose of the conservation of *Satoyama* where characteristic ecosystems have been maintained through human activity, such as agriculture, forestry, and fishery'.

The tenth meeting of the Conference of the Parties to CBD was held in Nagoya city in fall 2010. Japan proposed the 'Satoyama Initiative' to the world and made an appeal that the secondary natural areas, which is maintained through human interaction and categorised as a resource area (such as *Satoyama* in Japan), is important to the conservation of biodiversity. Concurrently, the MOE announced an action plan that the conservation and application of *Satoyama*, which constitutes approximately 40% of Japan's land area, would be investigated with the Ministry of Agriculture, Forestry and Fisheries, the Agency for Cultural Affairs, and the Ministry of Land, Infrastructure, Transport and Tourism, and would be promoted as a people's movement. The key behind the conservation and application of *Satoyama* is the 'regeneration of the relationship between humans and nature', but it is difficult to maintain and manage the secondary natural areas of *Satoyama* exclusively by farmers and the local community under the current social situation. Therefore, the formation of 'New Commons' to which various subjects such as private groups, companies, government, and specialists participate is expected. It is hoped that the decline in Japanese insects will be halted and recover by the conservation and application plans for *Satoyama*.

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Chapter 16
Development of Insect Conservation in Hawai'i

Francis G. Howarth and Betsy H. Gagné

16.1 Introduction

As the most isolated group of high islands in the world, the Hawaiian archipelago occupies a very special place in insect conservation: first as a cradle of evolution of a remarkable endemic fauna and second as a prime example of the vulnerability of island environments to anthropogenic changes – especially the effects of alien species. Lessons from both these themes are of global relevance, and the recognition that these same phenomena are occurring in continental systems has been important in maturing attitudes to insect conservation. Mirrored in other parts of the Pacific, such as New Zealand (Watts et al., Chap. 10; Howarth and Ramsay 1991), external disturbances have had massive impacts on the Islands' biota. These losses – together with the prospect of continuing severe losses – have contributed to debates over the rationale justifying alien species introductions, including non-native biological control agents. The impacts of introduced control agents are increasingly recognised as an important issue in insect conservation over the last few decades.

16.2 Early Interests

Appreciation of the global significance of the Hawaiian insect fauna and its contributions to understanding insect evolution and radiations in remote environments began with extensive surveys initiated in the late nineteenth century. The pioneering

F.G. Howarth (✉)
Hawaii Biological Survey, Bishop Museum,1525 Bernice Street,
Honolulu, HI 96817, USA
e-mail: fhowarth@bishopmuseum.org

B.H. Gagné
Hawaii Department of Land and Natural Resources, Natural Area Reserves System Commission,
1151 Punchbowl St, Room 325, Honolulu, HI 96813, USA

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Fig. 16.1 Robert C.L. Perkins, 1866–1955. Legendary entomologist who worked in Hawai'i at the turn of the twentieth century (Photo: Bishop Museum Press)

explorations of R.C.L. Perkins (see Evenhuis 2007) led to publication of the remarkable *Fauna Hawaiiensis* in three large volumes. Perkins (Fig. 16.1) was a remarkable individual who 'had an intricate knowledge of the behaviour and biology of a … broad range of species' and 'he was the last to see many of these alive' (Howarth 2007). Very soon after his arrival in Hawai'i in 1892, Perkins recognised the damaging effects of invasive animals and plants. He witnessed the devastation to many native insects caused by the introduction of alien ants into a fauna entirely lacking native ants. Perkins recognised that substantial further losses of endemic insects were likely to occur and even made prescient observations on the impacts of biological control agents on native non-target species (Perkins 1897).

Perkins' remarkable initiatives in documenting the insect fauna were supplemented by a team of outstanding entomologists assembled by the Hawaii Sugar Planters Association to control pest species. Most notable were O.H. Swezey and F.X. Williams, who, in addition to their official duties, described new species and documented biological information for many native species. Further work was undertaken by E.C. Zimmerman (Fig. 16.2), whose primary goal was to produce a series of handbooks that would permit identification of all Hawaiian insects and provide background that would open up the fauna to detailed biological study. At the start of this massive endeavour, which 'Zimmie' pursued so indefatigably for more than 30 years, the *Fauna Hawaiiensis* was the only foundation available on most insect groups. His analyses (from 1948 on) represent a body of work rarely equaled by any single entomologist. In his preface to the first five volumes of *Insects of Hawaii* (Zimmerman 1948), he noted, with characteristic modesty, 'I determined to assemble a working outline of the Hawaiian insects.' However, in the decades to come, his frustration at not being able to complete the task became increasingly evident in his writings. The series was driven single-mindedly by Zimmerman, with

Fig. 16.2 Elwood C. Zimmerman, 1912–2004. Initiated the monumental *Insects of Hawaii* series and authored most of the volumes (Photo: Bishop Museum Press)

his personal contributions to it beginning with the initial five volumes and culminating in the two massive volumes on Microlepidoptera (Zimmerman 1978) and the first volume on Coleoptera (Liebherr and Zimmerman 2000). The introductory volume (1948) remains a classic description of the biogeography and evolution in the Hawaiian archipelago. It was long out-of-print before being reissued in 2001 with biographical tributes to Zimmerman. All early volumes, including those on Diptera by D. Elmo Hardy (e.g. 1965), are indispensable to modern students. The series continues with Collembola (Christiansen and Bellinger 1992) and *Hylaeus* bees (Daly and Magnacca 2003).

16.3 Increasing Appreciation

Those first five volumes demonstrated an increase of about 120% in total number of species within the insect orders treated compared to the fauna enumerated in *Fauna Hawaiiensis*. In 1948, Zimmerman noted that the total number of known Hawaiian insects 'approached the 6000 mark'. By 1992, Nishida could enumerate 7,653 species, of which 4,987 were endemic. By 2002 the tally included 8,706 species of which 5,366 are endemic and 83 indigenous (Nishida 2002). The 2,700 listed non-native species include 379 that are documented purposeful introductions. The total has continued to rise with modern analyses of the complex species radiations that were fostered by the isolation and the intricate topography and environments of the rugged, sequentially-aged volcanic islands.

The Hawaiian Islands host some of the largest and clearest examples of adaptive radiation (the evolution of a suite of new species each adapted to its own environment), and some have become classics in illuminating transitional pathways in evolution. The fly family Drosophilidae, for example, (for background: Hardy 1965, 1974; O'Grady et al. 2011) contains more than 500 named Hawaiian species, of a putative total of 1,000 species present, as the foundation for extensive studies on genetics and speciation. Surprisingly, molecular research has now demonstrated that the group descended from a single colonising species, and that some descendents subsequently dispersed back to the continents to found new species there (O'Grady and DeSalle 2008). Zimmerman (1958, 1970) and Hardy (1974) emphasised the urgency of studying Hawaii's endemic biota because of the already considerable loss of species, particularly among the lowland fauna, with many species persisting only in hard-to-access highland areas. The *Drosophila* assemblages and some cave arthropods noted below were brought to wider attention in the first global *Invertebrate Red Data Book* (Wells et al. 1983). Finally in 2006, 12 of the larger showy species of *Drosophila* were formally listed and protected under the United States Endangered Species Act, and another added in 2010 (*D. sharpi,* from Kaua'i).

The unique features of Hawaiian Drosophilidae, highlighted by a team of experts over many years, are mirrored by many other insect groups. For example, radiations are equally intricate and spectacular within Heteroptera (Gagné 1997; Asquith 1997), Hymenoptera (Daly and Magnacca 2003), Coleoptera (Liebherr and Zimmerman 2000), Orthoptera (Otte 1994) and Lepidoptera (Zimmerman 1978; Rubinoff and Haines 2005). The general trend amongst taxonomic work on the insect fauna has been to increase the numbers of species within any group examined in detail, but many of the species are both rare and narrowly endemic, and thus vulnerable. Howarth and Ramsay (1991) highlighted at least 15 insect genera each likely to contain more than 100 native species. Two radiations may exceed 1,000 species each: *Drosophila* and *Hyposmocoma*. In short, the remarkable laboratory of evolutionary entomology provided by this archipelago continues to provide lessons of global relevance to understanding insect diversity, but increasingly in a climate of severe threat and inferred, but largely undocumented, losses of endemic taxa. Exploration continues, mainly through the impetus of the Hawaii Biological Survey housed at the Bishop Museum, Honolulu, and researchers at the University of Hawaii. The new findings are counterbalanced by failures to re-discover native species previously described (Liebherr 2009), and by revelations of continuing spread of alien species to even the more remote parts of the islands and altering formerly pristine environments (Henneman and Memmott 2001).

In addition to *Drosophila*, other insect groups also are being used as important flagship taxa to improve the public's image of insects and help focus on priority needs. The endemic damselflies in the multispecies radiation of *Megalagrion* have become symbols for wise stewardship of freshwater habitats (Polhemus and Asquith 1996). These authors noted that some *Megalagrion* species have declined markedly in recent decades – for example, *M. xanthomelas* (Fig. 16.3) (described by Perkins as 'common') is now extinct on Kaua'i, reduced to a single population on O'ahu and Lana'i and down to only a few populations each on Maui and Hawai'i. The two major causes of losses of damselflies are reduction and despoliation of aquatic habitats by the need for water for agriculture and urbanisation, and introductions and spread of alien plants and animals. Streams were modified

Fig. 16.3 *Megalagrion xanthomelas* (male), a native lowland damselfly, whose larvae breed in permanent pools. Once common, it is a candidate for endangered species status (Photo: D.J. Preston)

by drainage diversions, such as for irrigating sugar cane and generating hydro-electricity. Invasive plants (such as California grass, *Brachiaria mutica*) eliminate open water by dense growth. The most serious threat to many native damselflies (as well as other native aquatic species) is predation by over 50 species of alien fish (Englund 1999). For instance, loss of *M. pacificum* from most of the main Hawaiian Islands is attributed to predation by mosquito fish (*Gambusia affinis*) and sailfin molly (*Poecilia latipinna*) introduced for biological control of mosquitoes. Their impacts are enhanced by many more recent introductions of predators and diseases. Polhemus and Asquith (1996) noted that 'alien fish now determine the distribution of native aquatic damselflies in Hawai'i'. In July 2010, two *Megalagrion* species (*M. pacificum, M. nesiotes*) were listed as endangered under the U.S. Endangered Species Act (below, and Black, Chap. 8), and a few more are candidates for listing.

16.4 The IBP Impetus

The Insects of Hawaii volumes and results of the Drosophila Project played a role in the inclusion of Hawai'i as a site in the International Biological Programme (IBP) in 1970. Funded by the U.S. National Science Foundation, IBP projects conducted intensive multidisciplinary ecological surveys of selected sites (Mueller-Dombois

Fig. 16.4 Wayne Charles Gagné 1942–1988. Visionary insect conservationist shown here collecting on the island of Kaua‘i (Photo: F. G. Howarth)

et al. 1981). Significantly, the programme placed numerous researchers in the field, which facilitated a renaissance in Hawaiian natural history, especially in entomology. These were heady times as major discoveries resulted from nearly every field trip; for example, predatory caterpillars that ambushed active prey, blind cave animals in young lava tubes, an aeolian (wind-supported) ecosystem on barren lava flows, and numerous new insect species, many of which added new higher taxonomic groups to the native fauna. These results confirmed Zimmerman's assessment that the insect fauna was still poorly known, and more importantly, they demonstrated that the islands' fauna was not truly 'disharmonic' and that niches were not empty as had been assumed (see below). The roles of the missing higher taxa were filled by adaptive radiations within the native fauna: moth larvae filled in for mantids and other ambush predators; and lava tubes were populated by blind descendents of big-eyed native species.

IBP also provided the data, both directly and indirectly, for new conservation initiatives. The 1970s was the activist period, with IBP entomologists W.C. Gagné (Fig. 16.4) and S.L. Montgomery, in particular, leading the efforts to include native insects in conservation initiatives (Gagné 1975). The Hawai‘i Natural Area Reserve System Commission was established in 1970 with Bishop Museum entomologist, J.L. Gressitt as the first chairman, and Montgomery and Gagné along with collaborating biologists were instrumental in delineating areas worthy of inclusion. Gagné and Cuddihy (1990) later collated the data to define 180 separate vegetation communities – a remarkable diversity for such a small area. Their compilation did

Fig. 16.5 William P. Mull 1921–2008. Photographer and conservationist shown here collecting insects at 4,000 m on Mauna Kea (Photo: N.C. Howarth)

not include the more than 50 native communities not defined by plant cover; for example, aquatic, subterranean, and barren-rock habitats. The Animal Species Advisory Commission was established about the same time largely due to lobbying by the same activists. This government-appointed body, composed of delegates from affected state agencies, biologists, hunters and other stakeholders, was mandated to review a proposal to introduce Axis Deer to the island of Hawai‘i for sport hunting. After many highly contentious hearings, the proposal was denied, but the commission remained active for another decade advising state agencies on land management issues.

A fortunate collaboration aiding insect conservation began circa the start of IBP when amateur naturalist and macro-photographer William (‘Bill’) P. Mull (Fig. 16.5) joined Gagné, Montgomery and Howarth in an effort to photograph as many native species as possible. Bill set up terraria in his house and often watched the animals for days until he felt he understood their natural behaviour, and then he would spend however long it took to photograph the animals in their most interesting natural pose. Professionally, Bill was a linguist and enjoyed coining common names for Hawaii's ‘magnificent minutiae;' he also became locally famous for his animated slide shows given at schools, public events and entomological meetings over a period of 25 years. His photographs also graced scientific journals, popular magazines and books and helped raise awareness of the plight of

Hawaiian insects (Howarth and Mull 1992). *Drosophila mulli* was discovered by Bill and subsequently named in his honour. It is one of the 13 species of *Drosophila* on the endangered species list.

The 1980s brought dramatic changes. The activist period ended, its demise aided in part by the changing political climate in the U.S. In 1985, Bishop Museum reduced its research staff, especially entomologists, and shifted its focus more towards public programmes. Fortunately, many of the fired research staff stayed with the museum by obtaining funding through grants and contracts, but serious damage to biodiversity research had been done. Once again Hawai'i served as the harbinger of global change, as a wave of similar reorganisations swept through many of the world's larger natural history museums over the next 15–20 years. It seems ironic that, just as biodiversity was rising in the public consciousness, the ability of the main institutions holding the data and expertise to address the crisis was being reduced. But it has become a familiar story in the recent history of environmental issues, from public health to global warming (for example, see Michaels 2008).

The focus of arthropod conservation began to change during the same period. First, improvements in technology allowed the Hawaii Biological Survey to initiate the Hawaii Terrestrial Arthropod Checklist, which is designed to include a complete list of the correct available names for all Hawaiian arthropods. Second, relevant federal and state agencies became more proactive in insect conservation. The U.S. National Park Service and other federal agencies, as well as the Hawaii Department of Land and Natural Resources, hired entomologists to assist on insect conservation issues. Adam Asquith was the first entomologist to be appointed to the endangered species programme in the Hawaiian office of the U.S. Fish and Wildlife Service, Pacific Islands Ecoregion. While there, he was able to raise awareness in an agency that traditionally had focused on vertebrate conservation (Asquith 1995). Dan Polhemus joined Bishop Museum initially to assess the status of the Hawaiian stream fauna, particularly damselflies (Polhemus 1993, 1997). Ron Englund assisted him on these studies and was active in field surveys and conservation programmes (Englund 1999). Polhemus subsequently published extensively on insect conservation and evolution of Hawaiian and Pacific insect fauna, as well as collaborated with Jim Liebherr to organise symposia on these topics (Liebherr and Polhemus 1997; Liebherr 2009).

The annual conferences held to disseminate results of IBP research as well as to discuss conservation issues grew through several stages to become the Hawaii Conservation Alliance. The Alliance is a partnership of many government and private stakeholders, and was formed to improve communication on environmental issues among its members and the public, as well as to facilitate conservation programmes. Confrontational and sometimes acrimonious public hearings still occur, but with less frequency. Native insects and other arthropods are now included in many environmental impact assessments for new projects. This change is largely due to the successful lobbying during the activist period and to new legal mandates instituted as a result of insects being listed as endangered species (even though only on the U.S. Mainland at first), as well as to the increasing awareness among government agencies of the impacts of invasive alien species on the natural

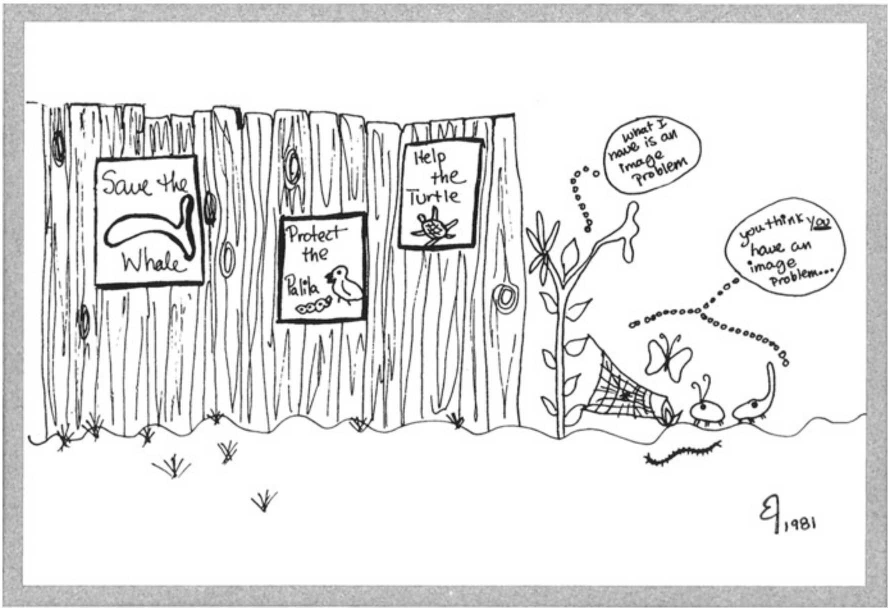

Fig. 16.6 The image problem in insect conservation. Cartoon drawn by B.H. Gagné

environment. Each major island now has an invasive species committee, whose purpose is to improve responses to problematic alien species including monitoring, control, or eradication of populations, as well as to provide public outreach and education on their programs.

Although the situation is improving in Hawai'i, biases still plague appropriate action. Locally, birds, plants, and some charismatic marine organisms still receive a disproportionate share of conservation funding and priorities (Fig. 16.6). More serious is the strong bias still existing against island conservation among some mainland U.S. ecologists and environmental groups. Many of these share the view that environmental issues affecting oceanic islands are unique to islands and not relevant to problems facing continental species. Some believe that island species are going extinct anyway, or believe that island faunas are so depauperate and disharmonic that islands are not worth protecting. That image is changing. In reality, islands are microcosms of ecological phenomena occurring on continents. That is, the same evolutionary and ecological games are played using similar rules but by quite different players. Because of the smaller arenas, each 'game' (or outcome from a novel perturbation) progresses to completion much more quickly on islands than on continents, sometimes within the lifetime of a researcher. This happenstance increases the visibility of environmental impacts on islands, which makes their study more feasible (Howarth 1990).

16.5 Alien Invasions

Hawaii's many unique environments are each susceptible to alien invasions and other disturbances, with the apparent disharmonic nature of resident native insect fauna emphasised by earlier workers (e.g. Gressitt 1971; Zimmerman 1948). Gagné (1988) noted that the suites of closely related species resulting from adaptive radiations are especially susceptible to introduced predators and other threats. Alien species do not respect reserve boundaries, but can invade into all available habitats that suit them. Their impacts are insidious but often overlooked – especially invading insects and other less conspicuous species. Because their impacts are often cryptic and ephemeral, the conventional paradigm is reinforced; that is, there is bias favouring habitat destruction as the most important cause of species extinctions whereas the effects of invasive alien species are minimised. Work in Hawai'i has implicated invasions as at least as destructive, if not more so, than habitat destruction. However, often the wave of invasion must be witnessed to recognise the effects (Perkins 1913; Cole et al. 1992). Once an invasion runs its course, it may be difficult to determine the true culprit or rule out habitat destruction. For example, an aggressive race of the social wasp *Vespula pensylvanica* arrived in Hawai'i in the late 1970s, probably with imported Christmas trees from the U.S. Mainland. (The small percentage of containers of trees inspected each year often contain a menagerie of hibernating animals from the Pacific Northwest.) *V. pensylvanica* is a damaging generalist predator of major concern as a threat to native insects and other invertebrates, as well as to native forest birds by diminishing their normal food supply. Within 5 years after discovery, the wasp had invaded upper elevation dry and mesic forests on all the high islands, and during drought periods has been able to invade wet forests. During the invasion phase, the numbers of wasps were astounding, one or more wasps foraging per square metre of foliage, which translates to over 100 wasps/m^2 in some areas! Nests of this ground-nesting species sometimes exceeded 1 m in diameter. Most native insects declined sharply or disappeared during this period, including several relatively common species of native *Drosophila* used in genetics research (Carson 1986). Although the impacts of this wasp seem clear (Gambino 1992), it is not possible to be absolutely certain in hindsight which species declined or went extinct because of this wasp. The impacts of most other introductions are not as well defined. The caddisfly *Cheumatopsyche pettiti*, believed to have been introduced with aquatic plants, is so abundant in some streams that this generalist algal feeder is thought to displace native aquatic taxa, but this remains to be confirmed.

Now that concerned entomologists are studying longer-term trends, the rather gloomy picture revealed on islands is being recognised in continental systems, especially the importance of the impacts of invasive species as threats to insect conservation. Susceptibility of the island biota to such aliens, including introduced biological control agents, has been an example of global significance in considering this pest management practice. Hawai'i has suffered from its political position as part of the United States because, although geographically and biologically very different from the continental mainland, few controls on importation of goods to the archipelago have been present over many years, so that numerous organisms have arrived undetected and unsought by quarantine. The great variety of invasive animals and plants in Hawai'i is highlighted by Staples and Cowie (2001), with a call for greatly increased vigilance to prevent arrivals of harmful taxa. The mode of arrival of many species is simply unknown, and the 'adventive' component of Hawaii's insect fauna is substantial.

New detections of alien species have been recorded assiduously in recent years, many in the Proceedings of the Hawaiian Entomological Society. The number of aliens is surprisingly high. Beardsley (1979) noted 289 species of immigrant arthropods established from 1962 to 1976, some being pests for which future biological controls might be sought. However, many if not most immigrant insect species arriving during that period came in undetected. More recently, Howarth and Preston (2007) conducted a comprehensive biological inventory of the terrestrial arthropods occurring within the environs of Kahului Airport on Maui, an area of 586 ha. The survey was mandated to mitigate the potential increase in the risk of invasive species introductions resulting from expansion of the airport to handle transoceanic flights. The number of species of insects and related arthropods identified during the field surveys currently totals 875, of which about 100 (11%) are native. Surprisingly, about 350 species (~40%) were added to the number of non-native arthropods known from Maui, of which about 80 species are also new to the state. The ratio of new to known native species was also about 40%. Among the new native species was a showy long-horned woodborer, *Plagithmysus kahului,* which is still known only from the airport area. The officially endangered Blackburn's Sphinx (*Manduca blackburni*) also occurs there as do six species of *Hyposmocoma*. These results underscore the gaps in our knowledge of insect diversity and distribution in Hawai'i and demonstrate the value of detailed biological inventories. They also show that at least some native insects can persist in relatively small areas. Such surveys also highlight the importance of taxonomy and systematics in insect conservation. Knowing whether a newly discovered species is foreign and possibly harmful or whether it is a native species is paramount in conservation biology and human welfare. The current ease of travel means that alien species can come from anywhere, often making it difficult to identify them.

Biological control has had a venerable history in Hawai'i. DeBach (1964) noted: 'There have been more introductions of insect predators and parasitoids to the Hawaiian Islands than to any other place in the world.' Swezey (1931) listed over 300 species that were documented introductions of biological control agents made up to 1925. However, he noted that perhaps ten times as many species were experimented with, but the outcomes or identities of these were undocumented. These earlier introductions occurred before appropriate screening protocols were in place to reduce the chances of non-target effects. Furthermore, many purposeful introductions were not recorded, and in several instances, more than one species was introduced under a single name. For example, Swezey's (1931) list includes such entries as 'earwigs', 'several species of *Hyperaspis*', 'Chalcids', 'dung beetles', and 'tumblebugs (several species)'; thus we have few data on the true history or non-target impacts of biological control in Hawai'i. Even so, by the middle of the twentieth century, the environmental impacts of these organisms were likely to have been substantial. Zimmerman (1978) inferred losses of native Lepidoptera to alien parasitoids, and similar alarms were raised also by Gagné and Howarth (1985) and Asquith and Miramontes (2001). Concerns were brought forcefully to global attention by Howarth's (1983) Presidential Address to the Hawaiian Entomological Society, followed by a broader review (Howarth 1991). Since then the topic has generated much, often polarised and sometimes highly emotional, debate on classical biological control practice, with vulnerability of endemic taxa through non-target impacts receiving wide attention (Lockwood et al. 2001). One of the major contributions from Hawai‘i to global insect conservation has been this increased awareness of vulnerability of native biota and the major impacts of biological control agents and ecologically parallel adventives. The development of improved monitoring procedures and routine recognition of the needs for ecological study of possible impacts owe much to these concerns from Hawai‘i.

16.6 Protection

A serendipitous discovery in 1971 during the early days of IBP was the existence of a community of blind cave-adapted insects living in young lava tubes on Hawai‘i Island (Howarth 1972). This represented a remarkable new biotope that was entirely unexpected in Hawai‘i. Subsequent surveys have found additional native cave species on Kaua‘i, O‘ahu, Moloka‘i and Maui, and the native cave fauna currently totals over 75 species (Stone and Howarth 2007). These animals are restricted to island-like habitats on islands and thus could be considered in double jeopardy, especially those on the older islands where cave habitats have eroded to tiny remnants. Subsequently, cave management plans were drawn up for caves in protected areas, and a few new reserves established (Howarth and Stone 1982; Stone et al. 2007). Cave ecosystems can be impacted not only by human activities within the caves, but also by land management changes on the surface, as well as by invading alien species (Howarth et al. 2007). An unfortunate event occurred just before the first cave surveys were done on Kaua‘i, when the fields with the largest caves known on Kaua‘i were covered by 5 m of sugar cane debris. Concerning the event, Howarth (1973) wrote ‘the caves are now gone, the fauna extinct, and no one will ever guess what that fauna might have been!’ Shortly after their discovery, the two known surviving cave animals on Kaua‘i were proposed for listing under the U.S. Endangered Species Act. They are the No-eyed, Big-eyed Hunting spider (*Adelocosa anops*) and the blind terrestrial amphipod (*Spelaeorchestia koloana*). After several more petitions over the next 20 years, the U.S. Fish & Wildlife Service agreed, and in 2000, the species became the first Hawaiian arthropods to be granted legal protection. If the cave fauna had gone extinct before discovery, no one would have believed it ever existed, and our understanding of island biology would be significantly poorer. What other unusual species are we missing because no one is looking? Such unknowns are general, across all organism groups and habitats on the islands, but emphasise the importance of protecting the remaining remnant biotopes and of keeping them as free as possible from alien invasions and other disturbance.

Although a large percentage of Hawaiian species certainly qualify, only a few insects enjoy protection under the Endangered Species Act. The 13 species of *Drosophila* and two *Megalagrion* species were mentioned above. In 2000, Blackburn's Sphinx moth was the first Hawaiian insect to be listed federally under ESA as endangered and has been the subject of a draft recovery plan (Richardson and Hopper 2003). It was believed to have become extinct in the late 1970s but was rediscovered on Maui in 1984, since then it has been found also on Hawai'i and Kaho'olawe (Rubinoff and Jose 2010). The moth is associated with lowland areas subject to massive human modifications including widespread loss of dry forest, and current threats include predation by alien ants, and attack by several species of parasitoids. Conservation management focuses on increased understanding of *Manduca*'s biology and restoration of habitat including restoration of the major food plants, such as *Nothocestrum* spp. with the intention of establishing additional moth populations in the future (Rubinoff and Jose 2010).

Not all potential flagship taxa currently are appropriate for listing as endangered. The most famous example, 'the Fabulous Green Sphinx of Kaua'i' (the sphingid moth *Tinostoma smaragditis*) remains too poorly known to list. The species has been declared extinct several times only to reappear. The latest specimens were found in 1997 (Heddle et al. 2000). It will certainly qualify for listing when its host plants and requirements become better known. Many of the remarkable insect oddities so characteristic of Hawai'i also represent excellent flagship taxa: the predatory ambush caterpillars (*Eupithecia* spp.) (Montgomery 1983), predatory snail-lassoing caterpillars (*Hyposmocoma molluscivora*) (Rubinoff and Haines 2005), the underground tree crickets (*Thaumatogryllus* spp.) and other blind denizens of lava tubes, and the Wekiu bug (*Nysius wekiuicola*) on the frozen summit of Mauna Kea (Howarth 1987). Hawai'i has no shortage of taxonomic and biological oddities that are genuinely deserving cases for conservation.

Measures to protect the remaining native Hawaiian species are vital. The most effective action for long-term protection is appropriate management of natural resources in protected areas including, for example those in the U.S. National Parks, U.S. Fish and Wildlife Service wildlife refuges, The Nature Conservancy reserves, The Natural Area Reserve System, and the Hawaii Watershed Partnership Program. However, conserving communities in Hawai'i can be a complex exercise; Howarth and Ramsay (1991) noted that nearly half (88 of 180) of the natural plant communities recognised were globally endangered and not represented in any reserves – see also Gagné (1988). Many ecologically specialised and host-specific insects are vulnerable to loss of any one of these, and depend on continued protection of reserves that do exist. Certainly many host-specific insects were lost when their hosts went extinct (Asquith 1995). Also, programmes to protect one group may seriously impact another; the conflicts inherent with biological control programmes were described above. In addition, habitat restoration programmes should include enhancing populations of the associated native insects. The native pollinators, when known, are obvious candidates in restoration programs, but phytophagous species as well as

Fig. 16.7 *Vanessa tamehameha* (male), the Kamehameha butterfly, which is the official state insect (Photo: Wm.P. Mull)

other associated native guilds deserve to be included. Moreover, native insects are a critical food resource for the native forest birds. An often over-looked important goal of conservation biology is to keep the common species common so that they can be enjoyed by the public (e.g., the state insect, *Vanessa tamehameha,* Fig. 16.7). Furthermore, as the *Vespula* and other recent invasions have so amply demonstrated, commonness is no protection if a species is vulnerable to a novel threat.

An encouraging new initiative is the development of the Statewide Invertebrate Conservation Strategic Plan, which is part of Hawaii's Comprehensive Wildlife Conservation Strategy (Mitchell et al. 2005). This begins a new chapter for insect conservation in Hawai'i. The Hawaii Division of Forestry and Wildlife hired entomologist, Cynthia King, to oversee the development of the Strategic Plan. Since much of the needed information is unknown for the vast majority of invertebrates, the Strategic Plan necessarily takes a more general approach and provides overviews of the issues facing the lowest taxonomic group for which data are available; that is, from species to order depending on group. Currently, many of the treatments are too broad when compared to those for individual species of vertebrates, but the Strategic Plan is designed to evolve and be fleshed out as additional information becomes available. Each account includes a statement of general threats, conservation actions needed (emphasising needs for surveys and habitat protection and restoration), and research priorities. All the taxa are thereby signaled formally for conservation consideration and treatment. The 'habitat approach' implicit in this Strategic Plan may indeed be more practicable than the more conventional species focus in promoting practical insect conservation in an arena in which the numbers of deserving candidate species may prove to be enormous and overwhelming. However, listing and protecting individual endangered species remain useful tools as flagship taxa and for assessing the efficacy of conservation strategies.

16.7 The Future

Although many threats appear to be increasing from human population growth and concomitant resource use as well as from increasing rate of alien species introductions, the future is not bleak. Mitigating the threats are the new initiatives, such as the Statewide Invertebrate Conservation Strategic Plan, and Conservation Alliance, and the new generation of concerned students and field biologists. The paradigm shift within government agencies to protect watersheds, control invasive species, improve quarantine, review biological control introductions, and support restoration efforts give native species a second chance. Two statewide bodies, the Hawaii Invasive Species Council and the Coordinating Group on Alien Pest Species, are active in reducing the threats from harmful alien species. Protection of native arthropods remains a tough sell, but their image is rising. In the words of Wayne Gagné in an unpublished manuscript from the 1970s:

> Billing something as the greatest this, smallest that, largest, shortest, narrowest, most scenic, highest – or even the onlyest – almost guarantees firing the imagination. What about our onlyest Hawaiian biota, doesn't it deserve similar billing?

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Chapter 17
Insect Conservation Biology: What Can We Learn from Ornithology and Birding?

David L. Pearson and Fabio Cassola

17.1 Introduction

In a search for patterns within the history of scientific studies, historians have analysed several fields from physics (Nye 1996), astronomy, and computer software (Leadbeater and Miller 2004) to biology (Killingsworth and Palmer 1992; Pearson and Cassola 2007). Are there steps common to all scientific endeavour? What recognisable patterns of change take place and what are the significant factors causing the changes? How can they best be compared?

Apart from satisfying intellectual curiosity, a solid understanding of factors in the development of science could prove useful for conservation biology in many ways. It could: (1) help determine priorities for funding agencies, (2) enable biologists to better communicate with and inform non-scientific decision makers, (3) focus individual researcher goals, (4) prepare cooperative research agendas, and (5) formulate more reliable and efficient models for management and conservation goals.

The goal of this chapter is to test if the experiences from one field of interest with a long history of advances and mistakes, such as ornithology, can be used to help guide the goals and emphases of a less developed field, such as the study of tiger beetles (Fig. 17.1).

17.2 Materials and Methods

History does not lend itself to experimental repeatability (Gould 1989), and thus tests of patterns in history rely on alternative methods. One of the most reliable techniques for answering pertinent historical questions and testing for patterns is

D.L. Pearson (✉)
School of Life Sciences, Arizona State University,Tempe, AZ 85287-4501, USA
e-mail: dpearson@asu.edu

F. Cassola
Via F. Tomassucci 12, 00144 Rome, Italy (Studies of tiger beetles. CXCII)

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Fig. 17.1 Adult Big Sand Tiger Beetle (*Cicindela formosa*) from Michigan, USA (Photograph by Rod Planck)

by using insights from one field to tell us something about another – a process called consilience by historians (Wilson 1998). In so doing, we can make sense of the past and perhaps anticipate the future (Gaddis 2004). One general model of the history of science proposed to predict historical patterns in biology is the General Continuum of Scientific Perspectives on Nature (GCSPN) (Killingsworth and Palmer 1992). According to the GCSPN, earliest biological studies begin with natural history and concentrate on observations in the field and specimen collecting, followed by observing and measuring in the field, manipulations in the field, observations and manipulations in the laboratory, and finally enter theoretical science, including systems analysis and mathematical models. Battalio (1998) refined this model and listed some specific characters that would demonstrate historical changes within the GCSPN model for scientific phases of biology:

(**STEP 1**) Natural history and search for new species predominate

(**STEP 2**) Now an experimental science rather than a natural history model

(**STEP 3**) Power is transferred from expert amateurs to trained professional scientists, and graduate training for employment in the field has become available

(**STEP 4**) Systematics and natural history no longer dominant, and research focused more on theoretically complex issues with extensive use of graphs and statistical inference in publications

(**STEP 5**) Formation of research teams and increasing evidence of socialization, such as use of acknowledgments sections, associations of peers, and co-authored publications

(**STEP 6**) Technical terminology and methodology so refined they now limit the audience that can fully comprehend it

Fig. 17.2 A tiger beetle captured by a Robber-fly (Asilidae) (Photograph by ES Ross)

We applied these steps and an additional one to two relatively discrete taxonomic fields whose history is well documented but whose biology and taxonomic levels are sufficiently different that the latitude of the model can be better assessed – birds and tiger beetles (Coleoptera: Carabidae: Cicindelitae). Birds are among the most thoroughly documented of all animal taxa, and about 10,000 species are presently recognized. Historical accounts of their study are numerous (Walters 2003). Tiger beetles are a small but distinct group of nearly 2,800 species whose historical background of studies is relatively well known (Pearson and Vogler 2001; Pearson 2006). These beetles are attractive, fast-flying and fast-running insect predators that occur in many diverse habitats around the world. Many of their adaptations, such as for thermoregulation, competition and avoiding their own enemies (Fig. 17.2) are well studied (Pearson and Vogler 2001).

Using a combination of narrative and comparative analysis, we contrast the history of tiger beetle (Pearson and Cassola 1992, 2005) and bird studies (Walters 2003) around the world and the growth of research on these groups from earlier centuries to today. We examine if the predicted pattern of steps applies and compares these scientific phases within a historical framework. Even though conservation problems and specific solutions are often different for these two taxa (Thomas 1995), do studies of both conform to the GCSPN model? If there are divergent patterns, to what can they be attributed? How can the model and its assumptions be improved so that we can better understand broad patterns in scientific development and use this understanding to meet the goals of insect conservation biology?

17.3 Results

17.3.1 (STEP 1) Natural History and Search for New Species Predominate

The earliest studies of birds in the fourth century BC were descriptive, anecdotal, and often associated with economic use, such as falconry and hunting or with art and religion. By the twelfth century AD, bird studies were more organised but remained descriptive. A desire for wealth and power encouraged geographical exploration and colonisation around the world. Exotic birds were among the treasures with which explorers returned. For instance, the North American turkey, at first imported as a novelty, became domesticated as a food source in Europe in 1530. Parrots and other brightly coloured birds aroused heightening interest as pets for Europeans, especially as status symbols among the upper classes. By 1756, specimen collections had become extensive, and positions such as professional curators began to appear.

In the tenth edition of his Systema Naturae, Carl von Linné (1758), one of the founders of modern binomial taxonomy, described 8 tiger beetle species and 564 bird species. By the end of the eighteenth century, an ever growing group of collectors and museum curators had described 50 tiger beetle species and more than 800 bird species (Table 17.1). During the first half of the nineteenth century, studies of birds and tiger beetles continued as almost completely a search for new species and under the nearly exclusive control of Europeans.

The number of new bird species described each year peaked in 1837 and decreased thereafter, so that by the 1950s only 2–5 new species were described each year. In marked contrast, throughout the rest of the nineteenth century and well into the latter part of the twentieth century, the number of new species of tiger beetles rose rapidly (Wiesner 1992). Nearly one third of the world's 2,791 tiger beetle species were described in the last half of the twentieth century and in the early twenty-first century (Table 17.1). Along with species description, some tiger beetle systematists also described significant natural history observations (Wallace 1869; Bates 1869; Hamilton 1925), a combination of effort that continues into the present (Erwin 1983; Desender et al. 1992; Cassola and Pearson 1999; Cassola et al. 2000; Zerm and Adis 2000, 2001).

This descriptive step was also critical for the establishment of interest in conservation biology. Much of the earliest history of conservation biology revolved around documentation of species, in this case their extinctions. In the midst of manifest destiny and impressions of inexhaustible resources, the unexpected disappearance of once abundant species of birds, such as the Passenger Pigeon, first made extinction seem a real possibility, and the causes of extinction of individual species became an important area of study for the nascent field of conservation biology. To a much lesser extent tiger beetles lent themselves to early studies of declining populations and extinctions. As such, several species and populations of tiger beetles became some of the first insects declared legally endangered or threatened with extinction.

Table 17.1 Numbers of species of birds and tiger beetles described in periods between 1758 and 2000 and 10 years from 2001 to 2011, and the percent of total known at present

Periods (years)	No. species of birds (% of total)	No. species of tiger beetles (% of total)
1758–1800	1,714 (17)	51 (2)
1801–1850	3,888 (29)	418 (15)
1851–1900	3,233 (32)	787 (28)
1901–1950	874 (9)	493 (18)
1951–2000	232 (2)	699 (25)
2001–2011 (estimated)	23 (0.2)	253 (9)
Total	9,964	2,791

Fig. 17.3 Controlled area in Santa Cruz Co., California, to protect the officially endangered Ohlone Tiger Beetle *(Cicindela ohlone)* (Photograph courtesy University of California Santa Cruz Grounds Dept)

Two North American subspecies of tiger beetles are now considered extinct (Knisley and Fenster 2005). Pearson et al. (2006) estimate that at least 33 (15%) of the 223 named species and subspecies of tiger beetles in Canada and the United States may be declining at a rate that justifies their consideration for inclusion on the US Fish and Wildlife Service's List of Endangered and Threatened species (Fig. 17.3). However, at present, only four of these are officially listed by the federal government, and several others are under consideration for listing. In addition, several other countries (Belgium, Canada, Germany, Great Britain, Lithuania, Netherlands, South Africa and Sweden), at least 24 individual states and provinces within the United States and Canada, and international NGOs (World Conservation

Monitoring Centre and IUCN) have developed lists of endangered and threatened species that include tiger beetles.

Few other insects are well-enough known globally to document these types of population decline. Because of the rich collections of tiger beetle specimens available for study, however, the disappearance of species from former parts of the range can be authenticated. From these historical records, some long-term changes in the environment can also be deduced (Nagano 1980; Desender and Turin 1989; Desender et al. 1994; Yarbrough and Knisley 1994; Kamoun 1996; Trautner 1996; Berglind et al. 1997; Diogo et al. 1999; Knisley and Hill 2001; Richoux 2001; Sikes 2002; Goldstein and Desalle 2003; Horgan and Chávez 2004; Mawdsley 2005). Thus, tiger beetles help offer a window into our past and can provide insight as to where protective measures are needed (Babione 2003).

17.3.2 (STEP 2) Now an Experimental Science Rather than a Natural History Model

The major intellectual advance during the last half of the eighteenth century for birds and tiger beetles was an often-conflicting attempt to place the growing number of species into a natural array of groupings. By moving to cause-and-effect questions, these attempts at phylogenetics were also some of the first signs of a change into an experimental paradigm (Erwin 1985; Barrow 1998; Arndt and Putchkov 1997; Barraclough et al. 1998; Barraclough and Vogler 2000), an area that has also become important for use in conservation (Pearson 1994; Cassola and Pearson 2000; Pearson and Carroll 2001).

By the end of the nineteenth century, the number of known tiger beetle species had risen to 1,256 and the number of bird species to more than 8,800. With a greater array of species known, better chances for comparisons, and greater competition for research subjects among the increasing number of experts, bird and tiger beetle systematists ventured into more sophisticated areas of research. Field naturalists such as A.R. Wallace (1869) and H. W. Bates (1869) often collected birds and tiger beetles wherever they traveled. Nascent but significant ideas about behaviour, ecology and evolution also grew from their experiences of collecting and observing.

In the centenary issue of the British Ornithologist Union journal, The Ibis, Moreau (1959) indicated that by then more than 75% of all publications in The Ibis were "scientific" ornithology that emphasised explanation. By the XXI International Ornithological Congress in 1994, major portions of presentations were on molecular genetics, physiology, neurology, endocrinology, immunology, evolutionary ecology and social behaviour, all fields of research that involved experimentation and none of which existed at the beginning of the century (Walters 2003).

In contrast to the burgeoning number of ornithologists and the breadth of their experimental fields throughout the first half of the twentieth century, tiger beetles continued as the interest of only a few taxonomists, including the German medical doctor, Walther Horn. He was to become the greatest authority and acknowledged specialist of the tiger beetle family, working almost solitarily for more than 50 years. Although predominantly taxonomic in nature, his articles began, later in the century, to incorporate ideas of habitat, biogeography and intraspecific variation (subspecies), a concept Spencer Baird and Joel Allen established in ornithology 75 years earlier.

Besides reconstructing the past, tiger beetles are useful for conservation in other ways. Because of political, sociological and economic pressures, conservation policy and research are under pressure to produce quick results. This pressure is so pervasive, and the time, money and personnel to do the work are so limited that conservation biology is called a 'crisis discipline', in which risk analysis has become a major element (Maguire 1991). A common approach to resolving these problems has been to use indicator taxa as test organisms that purportedly represent other taxa in a complex environment. By focusing studies on a small but representative subset of the habitat or ecosystem, patterns of habitat degradation and population losses can be more quickly and clearly distinguished (Noss 1990). Tiger beetles have been used throughout the world to test and develop better guidelines for choosing bioindicators (Holeski and Graves 1978; Schultz 1988; Bauer 1991; Pearson and Cassola 1992; Rivers-Moore and Samways 1996; Kitching 1996; Rodríguez et al. 1998; Cassola and Pearson 2000; Cassola 2002; Arndt et al. 2005).

17.3.3 (STEP 3) Power is Transferred from Expert Amateurs to Trained Professional Scientists, and Graduate Training for Employment in the Field has Become Available

In the 1860s, bird conservation organisations, such as the Audubon Society, were formed with both professional and amateur participants. In the next few decades, the work of these professionals and amateurs created many conflicts, such as the benefits of specimen collecting and use of common names. Gradually professional academicians and government employees with advanced degrees, such as Aldo Leopold and Rachael Carson, took over the study and communication of conservation problems.

For tiger beetles, the near monopoly of a single expert, Walther Horn, had great influence on the direction of studies (Horn 1926). Beyond his tight control of tiger beetle taxonomy, however, a few other professional biologists began to publish scientific articles using tiger beetles as test organisms for geological history (Wickham 1904), behaviour (Shelford 1902), physiology (Shelford 1913), and ecology (Shelford 1907).

Growing numbers of bird researchers quickly diversified their research questions, many of which required sophisticated field and laboratory skills that amateurs could not easily acquire. By the mid 1980s, the separation of professional ornithologists and amateur birders was made even more profound with the introduction of technical analyses, such as gel electrophoresis, radar for bird migration, sound spectrography, and statistical software packages. Not only had the preponderance of ornithological research shifted, both in systematics and other fields, from private hands to university professionals, but by 1999 there were 100 professional ornithologists in the world for every one there had been in 1960 (Walters 2003).

Over the same period, the advent of prismatic binoculars, cameras, field guides, popular birding magazines, conservation groups emphasising birds, and electronic web sites all helped advance the interest of amateurs in ornithology, but they became largely excluded from all but the most basic descriptions of identification, range extensions and environmental protection.

Even more subtly, professionalisation of ornithology was reflected in its scientific language, writing styles, and grammar. Linguistic analysis shows an evolving use of words and phrases that indicate levels of expertise and establish levels of authority that further separated professionals from amateurs. These words include adverbs that show degrees of reliability, such as 'undoubtedly' and 'possibly'; induction, such as 'must' and 'evidently'; identification of hearsay evidence, such as 'it seems' and 'apparently'; reservations of deduction, such as 'presumably and could'; and hedges, such as 'approximately' (Chafe 1986). In addition, professional science writers use distinctive writing devices that include reduced use of personal pronouns, reliance on passive voice, a decrease in the number of simple sentences, the presence of technical terminology, an emphasis on reliability of evidence, and the use of citations (Lakoff and Johnson 1980). Carter (1990) also showed that although professionals rewriting scientific articles for semi-popular or popular consumption tend to write in broader generalities and use methods more similar to amateurs, they retain a concept of domain-specific knowledge that distinguishes them from the style of amateurs. The preliminary signs of this transformation also are becoming evident among tiger beetle researchers (Desender and Turin 1989).

In studies of birds, a trend developed to separate professional ornithologists and amateur birders into different organisations, each with their own meetings and publications. Amateurs joined organisations such as the American Birding Association, and conservation organisations, such as the Audubon Society and The Nature Conservancy. Professionals were regularly invited to contribute articles and serve on boards of directors of these associations, but rarely were amateurs invited to return the favor in professional meetings or publications. Professionals congregated in their own societies, such as the American Ornithologists' Union, British Ornithologists' Union, and Deutsche Ornithologen-Gesellschaft.

At the same time, the few graduate studies on tiger beetles focused on their coloration (Schultz and Rankin 1983a, b), ecology (Hori 1982; Mury-Meyer 1987; Fahr 1998), physiology (Zerm et al. 2004a, b), neural anatomy (Strausfeld et al. 2009), and use in conservation efforts, such as a search for bioindicators (Knisley and Hill 1992; Mittermeier and Mittermeier 1997; Mittermeier et al. 2004; Rodríguez et al. 1998; Kremen et al. 1993; Andriamampianina et al. 2000; Torres and Ruberson 2005; Arndt et al. 2005; Bhargav et al. 2009; Michels et al. 2010; Topp et al. 2010), local extinction (Knisley et al. 1987; Spomer and Higley 1993; Knisley and Fenster 2005; Mawdsley 2005; Knisley and Haines 2007; Satoh 2008; Karube 2010), and reintroduction (Omland 2002; Fenster et al. 2006).

17.3.4 (STEP 4) Systematics and Natural History no Longer Dominant and Research Focused on Other Theoretically Complex Issues with a Growing Use of Graphs and Statistical Inference in Publications

The Zoological Record, published by the Zoological Society of London, shows that of 500 scientific articles on birds in 1900 nearly 85% dealt with systematics and natural history. By 1990, the total reached more than 14,000 articles, but only 5% of them focused on taxonomy or natural history (Walters 2003). In addition, ornithological journals included a significant percent of articles using birds as test organisms in fields other than systematics and taxonomy. New specialised journals emphasised such specialties in ornithology as bird protection, avian pathology, and avian ecology (Pearson et al. 2011).

Other evidence for this change to more complex problems was found in the frequency of illustrations and statistics included in articles. By the 1970s, photographs and lists of bird species had declined or disappeared from articles in The Auk. They were replaced by increasing use of complex graphs, cladograms, scatter plots, regression lines, and DNA fingerprints. By 1990, 77% of articles published in The Auk were based on statistical inference (Battalio 1998).

Among tiger beetles, in areas other than taxonomy and natural history, the latter part of the twentieth century saw a relatively small increase in articles published on behaviour, ecology, morphology (Cassola and Miskell 1990; Freitag 1992) and ecology (Palmer 1978; Pearson 1980, 1988). Starting in the 1980s, physiological studies of tiger beetles emerged (Dreisig 1980; Hadley et al. 1988; Gilbert 1997). In the 1980s genetics studies began to appear (Serrano and Yadav 1984; Galián et al. 1990; Proença et al. 1999a). These non-taxonomic publications contained 85% of the articles on tiger beetles with statistical procedures and graphs.

One area in which tiger beetles were at the forefront of more complex conservation biology studies was in the statistical application of assumptions of dependence among data points. In initial comparisons of species patterns across regions and countries, Pearson and Cassola (1992) claimed that among the tested attributes of tiger beetles was a high correlation between their species numbers and those of other groups. If one goal is to establish conservation areas with the highest species diversity, tiger beetles were very useful because where you found more of them you also found more species of other groups, such as birds and butterflies. But tiger beetles, at the right season, could often be surveyed in a few weeks whereas birds took years to survey adequately in the same area. In addition, it was easy to train students and local workers to observe and sample tiger beetles, but training these same people to observe other taxa, such as birds and butterflies, was an enormous undertaking. Thus, one could argue that tiger beetles are logistically useful and biologically appropriate candidates to help represent entire habitats or ecosystems for species inventories. Tiger beetles were among the first taxa for which use of modern analytical techniques showed a correlation between their diversity and that of other taxa (Carroll and Pearson 1998a, b; Carroll 1998; Pearson and Carroll 1998, 1999, 2001).

In addition to pioneering statistical analyses, tiger beetles also were used in early applications of molecular analysis for geographical implications of conservation. For instance, the subdivision of lineages of the tiger beetle species, *Cicindela dorsalis*, in Florida between the Gulf of Mexico and the Atlantic Ocean, can be detected only with molecular markers. However, the fact that species of several taxa on one side of a barrier are consistently different from those on another is highly significant for conservation (Pearson and Vogler 2001). These regions of distinctive genetic overlap can reflect historical events in evolutionary time (Crandall et al. 2000; Goldstein et al. 2000; Satoh et al. 2004). By incorporating an evolutionary time scale, we not only gain another valuable factor to include in our conservation planning, but it also makes us aware that areas chosen for protection require management goals focused not just on 10, 20 or even 100 years, but for much longer into the past as well as the future (Schwartz 1999; Barraclough and Vogler 2002).

17.3.5 (STEP 5) Socialisation Such as Use of Acknowledgments Sections, Associations of Peers, and Co-authored Publications

Unlike ornithologists, tiger beetle researchers showed little socialisation well into the twentieth century. There were no organised peer groups, meetings, or associations of those interested in tiger beetles, and only in the 1990s did field guides or general books on the biology of tiger beetles appear (Knisley and Schultz 1997; Leonard and Bell 1999; Acorn 2001; Choate 2003; Pearson et al. 2006). Before this time, only those with time and interest to search through often obscure journals and arcane terms could acquire the basic knowledge to do research using tiger beetles.

Another test of socialisation is in co-authored publications. Among ornithological publications, the proportion of those co-authored in The Auk in the 1890s was less than 15%. By the 1990s it reached 60% of articles, and almost 25% of all articles had more than three authors (Battalio 1998). For tiger beetles, a similar increase in co-authored articles has been significant with a recent book on general tiger beetle biology having 40% of its citations co-authored (Pearson and Vogler 2001).

In 1969, an informal correspondence among tiger beetle enthusiasts developed into a journal called 'Cicindela'. Its publication goals were to provide a forum to share observations, collecting sites, natural history, distributional data, identification help, and taxonomic insight of tiger beetles. The subscriber list to this journal quickly rose to about 200 but stayed at that level for the next 40 years, and they included primarily enthusiastic amateurs from North America and Europe. Small groups of subscribers would go on collecting trips together, but there were few attempts to organise meetings or symposia where these people could interact face to face. Nevertheless, another indicator of socialisation showed advances within this highly specialised journal.

In the 1970s only 2% of its articles had acknowledgments sections; in the 1980s 26% had these sections; and in the 1990s, 83% of them did. Despite these signs of socialisation, a continued aura of exclusivity among tiger beetle workers was apparent in the paucity of support programs for active recruitment of new and especially young enthusiasts. There are fewer than 1,000 tiger beetle professional and amateur enthusiasts in the world. In contrast, today the American Ornithologists' Union alone has more than 4,000 members, most of whom are professionals. Similar organizations in England, Latin America and many other parts of the world also have additional thousands of members. Among amateur bird watchers, the latest estimates by the US government in its 'National Survey on Recreation and the Environment – 2000' calculated that 69 million Americans had formally observed or photographed birds.

The complex nature of modern conservation biology research necessitates more and more research teams involving both professionals and expert amateurs (Pearson et al. 2011). For instance, many modern conservation biologists working on rare and endangered species now rely heavily on molecular markers (Avise 1994; Galián and Vogler 2003) to distinguish species and populations within species. The importance of conserving intra-specific variation is reflected in the U.S. Endangered Species Act, which calls for the conservation of 'independent population segments'. This makes conservation of distinct populations within a species a legal requirement, and involves coordination of field biologists, laboratory technicians, lawyers, and politicians. This coordination of effort is obvious in many areas of conservation biology, and recently has also become a dominant theme in tiger beetle studies (Knisley and Hill 1992; Vogler et al. 1993; Moritz 1994; Vogler and Desalle 1994; Vogler 1998).

These and other such sophisticated uses of tiger beetles have direct ramifications for conservation biology, and most of them will involve teams that are interdisciplinary. This team effort is in areas such as climate change (Ashworth 2001), reintroductions (Omland 2002; Brust 2002; Knisley et al. 2005), habitat reclamation (Hussein 2002), habitat management (Omland 2004; Cornelisse and Hafernik 2009) and location of conservation reserves and parks (Mittermeier and Mittermeier 1997; Desender and Bosmans 1998; Andriamampianina et al. 2000; Pearson and Carroll 2001; Mittermeier et al. 2004; Knisley et al. 2008).

17.3.6 (STEP 6) Technical Terminology and Methodology so Refined they Now Limit the Audience that Can Fully Comprehend it; Development of Mathematical and Statistical Models

For both birds and tiger beetles, the rapidly growing use of highly sophisticated fields, such as molecular biology, statistical modeling, and satellite imagery has introduced many technical words and concepts that can quickly limit comprehension to a narrow array of associated professionals. This trend, as measured in terms of scientific discourse, includes increasing length and number of published articles, increasing sentence complexity, use of multi-word noun phrases, as well as narrowly defined technical terms, is well advanced among ornithologists (Battalio 1998). Among tiger beetle workers, until recently this tendency has been less obvious than in ornithology, but many signals indicate that a growing separation is underway for them as well, especially in complex fields, such as molecular studies (Vogler et al. 1993; Vogler and Desalle 1994; Vogler and Pearson 1996; Vogler et al. 1997; Vogler and Barraclough 1998; Diogo et al. 1999; Proença et al. 1999b, 2004; Morgan et al. 2000; Goldstein and DeSalle 2003; Pons and Vogler 2006; Vogler et al. 2008), physiology (Irmler 1973, 1981, 1985; Hudson et al. 1988; Guido and Fowler 1988; Yager et al. 2000; Zerm et al. 2004a, b; Toh and Mizutani 1994; Mizutani and Toh 1995; Gilbert 1997) and mathematical modeling (Pearson and Juliano 1993; Pearson and Carroll 2001; Carroll and Pearson 1998a, b, 2000).

17.3.7 (STEP 7) Resurgence of Expert Amateurs

Paradoxically the growing sophistication of professional ornithologists, and to some degree among tiger beetle professionals, has manifested itself as a previously unrecorded Step 7 in the historical march of science. A rejection of taxonomy and natural history as valid pursuits for many professionals (Acorn 2009) and a general decline in funding for these areas of research has created a paucity of these critical data (Bossart and Carlton 2002; Pearson et al. 2011). In addition, beginning in the last third of the twentieth century, governments in many countries listed several tiger beetle and bird species as endangered or threatened. Legislators, economists, sociologists, foresters, politicians, land owners and many members of the public, who had little or no previous interest in these taxa, suddenly needed to know about them. Often by default, the pursuit of these basic taxonomic, distributional and natural history data has fallen to individuals searching for an avocation. Their interest levels range from an occasional observer to serious and committed citizen scientists who function at the level of some professionals (Pro-Ams) but are not paid for their work (Leadbeater and Miller 2004).

The sources of these amateurs lie in an understanding of economics. As the economy of a country or region rises, its middle class grows. Families will have fewer children and invest more time and money into each child including increased support of higher education (Barro 2001), donations to private organizations (NGOs), time and money for avocations (Leadbeater and Miller 2004), and concern for the environment (Bhattarai and Hammig 2004). Increased access to the internet (Godfray 2007) and published field guides (Pearson and Shetterly 2006) are especially significant factors in attracting and training Pro-Ams into biology and conservation.

Although there appears to be a general decline in the numbers of professional taxonomists (Hopkins and Freckleton 2002), Pro-Ams or citizen scientists are notably active and numerous among those studying birds, especially in relation to their conservation and protection. Professionals direct the energies and abilities of amateurs through data gathering web sites such as Ebird (Cornell Lab of Ornithology), Christmas bird counts (National Audubon Society), Etudes des Populations d'Oiseaux de Quebec (Droege et al. 1998), Hawk Migration Association of North America, and many other programs (Evans et al. 2005; Greenwood 2007). These informal data bases then become available for sophisticated modeling and statistical analysis (Pearson and Carroll 1998; Cohn 2008; Pearson et al. 2009).

The influence of these active bird amateurs appears to be spilling over into other taxa. Based on notices of regional/national meetings and ecotourist tours published on line, amateurs studying such insect groups as dragonflies, butterflies, and tiger beetles, are populated by a large proportion of birding enthusiasts. Some local Audubon Society-sponsored field trips in Virginia, Florida and Arizona focused specifically on tiger beetles. The appearance of published field guides for tiger beetles in North America (Pearson et al. 2006), Thailand (Naviaux and Pinratana 2004), Colombia (Vítolo 2004) and other parts of the world was quickly followed by a notable increase in the number of amateurs and professionals interested in tiger beetles as a hobby or research organism. A large proportion of these initiates had begun their observations of Nature with birds (Pearson and Shetterly 2006).

17.4 Discussion

Does the history of bird and tiger beetle studies follow a common pattern?

Despite substantial differences in their biology and taxonomic level, both bird and tiger beetle studies show similar patterns of change over their histories. However, for both taxa, overlap between adjacent steps makes analysis at a small temporal scale difficult, and at least 50-year intervals are necessary to distinguish the patterns. The most obvious divergence between them is the speed with which some steps were completed and the comparable maturity of research at any given time, differences similar to those suggested by theories of paradigm shifts (Kuhn 1996).

Amateurs have had powerful influences on both fields. They initiated natural history and taxonomic studies of birds and tiger beetles at the same time in the eighteenth century. In the nineteenth century amateurs, especially bird enthusiasts, were instrumental in initiating conservation societies and influencing legislation for protection of the environment. However, professionalisation of the field became apparent much earlier in ornithology as tiger beetle studies lagged in these changes by at least 75 years. Collectors and authors working alone have been very important over the entire history of tiger beetles. This pattern was also apparent in ornithology, but only through the middle of the nineteenth century.

The rise of such issues as trinomial use, biological studies, and graduate education are a few additional examples of differential rates of change by bird and tiger beetle researchers. The use of common English names versus scientific names was debated among ornithologists in the nineteenth century, probably because birds had attracted so much attention from the public early on. Amateurs complained of too much dependence on scientific names in ornithology (Barrow 1998). For tiger beetles, in contrast, scientific names were retained as virtually the only nomenclature until the twenty-first century (Pearson 2004; Wu and Shook 2010). More recently, the publication of tiger beetle field guides with English names helped recruit a huge increase in amateur involvement, most of whom eschewed scientific names of tiger beetles.

The minimisation by professionals of basic but critical studies of natural history and range distributions, and in many cases descriptions of new species (Acorn 2009) impacted ornithology earlier than tiger beetle studies. Today, largely because few undescribed species remain in the world, descriptions of new bird species are so few that bird taxonomists spend little time in this effort. Instead they concentrate on refining studies such as phylogenetic and evolutionary relationships, areas that are also more likely to be funded and recognised as intellectually appropriate. Also, most professional ornithologists no longer pursue studies of long term presence-absence data, range expansions and descriptions of natural history, even though these types of data are often critical for sophisticated modeling and hypothesis testing. Instead professional ornithologists are helping empower citizen scientists to gather long term data and basic descriptive natural history observations (Droege et al. 1998; Pearson et al. 2009). This trend is also apparent among tiger beetle professionals (Pearson et al. 1988), but less formally than the programs organised by ornithologists. If tiger beetles and other insect groups are to be widely incorporated into studies and management plans for conservation biology, the history of bird studies shows that facilitating the interaction of amateurs and professionals should be a high priority.

17.5 Causes of Differential Rates of Change

In contrast to ornithology, relatively few professional scientists have used tiger beetles as test organisms for biological hypotheses. Graduate studies and paid positions for tiger beetle workers have remained scarce. Based on our comparisons of the historical development of bird and tiger beetle studies, we propose that at least four causes can explain much of the difference in their speeds of change through the development of these fields of science:

1. Number of species – Both taxa have sufficiently small species numbers so that researchers can expect to understand general patterns of species relationships as well as details of biology and distribution, but with three times the species numbers, bird research has a wider range of examples and potential concepts to test.
2. Range of habitats – Although both tiger beetles and birds occur over a wide range of latitudinal and altitudinal habitats, some bird species extend into higher latitudes, altitudes and extreme habitat types not occupied by tiger beetles. Bird studies thus provide a wider range of questions and potential biological problems to solve.
3. Obviousness and economic importance – Although many birds and tiger beetles are colourful and attractive, tiger beetles are generally less conspicuous. In addition,

the early economic significance of birds in hunting and domestication is in stark contrast to the insignificant economic importance of tiger beetles. Thus birds may be more inherently attractive as a subject of interest.

4. The number of researchers – A combination of the previous three factors likely contributed to the number of researchers using each taxon. In early steps, they influenced how many taxonomists could compete for descriptions. For tiger beetles, fewer taxonomists led to slower rates of socialisation, less formation of peer groups, few specialised journals, little recruitment of additional enthusiasts, and slower and narrower development into more experimental studies.

What uses does the comparison of birds and tiger beetles in the GCSPN have for identifying and attaining conservation biology goals?

These results can help us answer questions, such as: At what points should funding agencies support specific efforts? Are there better periods than others in which to attract young recruits to maintain or increase interest in specific taxa or fields such as conservation biology? Can or should dominance by a single individual or small clique be avoided? Will professional biologists exclude the expert amateurs, or how can they be encouraged to cooperate? Can professional publications and communications be written so as not to exclude non-experts?

We now have a better idea of priorities for selecting which taxa or fields will yield the most useful and broadest results. With limited funds, time and personnel, how do we balance the costs and benefits of speciose habitats and taxa, economic importance, detectability, and human or natural threats (Sorensen 1995). How do we redefine the training and support of professional conservation biologists so that they are rewarded for developing and applying communication skills among scientists, Pro-Ams, legislators, decision makers and the public? How can we most effectively educate, recruit and mentor Pro-Ams who will probably provide the bulk of future taxonomic and natural history data for most taxa in the future?

With some immediate solutions and the promise of even more important long range solutions made possible by examinations of historical models, such as the GCSPN, we can be encouraged that conservation biology can make use of its history. With improvements in the model and future tests of the process of science itself, we may have the best chance to develop foresight, learn from history, and better know if and what changes can be made to better reach our goals. 'We know the future only by the past we project into it' (Gaddis 2004).

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Part V
Looking Forward

Chapter 18
Where to Next? The Future of Insect Conservation

Alan J.A. Stewart

18.1 Introduction

It is a brave, but possibly foolish, person who thinks they can predict the future with any confidence. The American businessman and writer Peter F. Drucker once suggested that 'trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window'. Nevertheless, attempting to foresee problems in order to prepare for them and deal better with their consequences is good discipline for any applied science, but perhaps especially for nature conservation given that it is so dependent upon extraneous influences. This is borne out by the current emphasis on 'horizon scanning' for future environmental and conservation issues (Sutherland et al. 2009, 2010).

Insect conservation, once considered a Cinderella discipline and therefore largely ignored by mainstream conservationists more focused on plants and charismatic fauna, has now come of age. Much more attention is now paid to insects than ever before, although there is still an understandable bias towards taxa whose general ecology, reasons for decline and specific habitat requirements are better understood, such as butterflies. It is clear that there is still a long way to go with some of the more obscure insect groups for which we have only scant ecological information.

This chapter focuses on some of the predictable challenges that insects will face in the immediate future, due to environmental and anthropogenic changes that we know are already under way and have been well documented. It also considers what issues are just over the horizon that may not be current concerns but are likely to assume greater significance in future.

A.J.A. Stewart (✉)
Department of Biology and Environmental Science, School of Life Sciences,
University of Sussex, Falmer, Brighton BN1 9QG, UK
e-mail: A.J.A.Stewart@Sussex.ac.uk

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18.2 Climate Change

The overwhelming weight of scientific opinion is agreed that the world's climate is warming, although there is still great uncertainty about how far and how fast this will proceed. There is certainly growing evidence for changes in the range distributions of species across a variety of taxonomic groups and that are consistent with a general warming of the climate. Britain's long tradition of biological recording and mapping means that it has probably the most extensive dataset in the world on the fine-scale distribution of species and long-term changes therein. Patterns of northward shifts in range within Britain that were initially documented for butterflies (Asher et al. 2001; Hill et al. 2002; Warren et al. 2001) have since been found in a variety of other insect taxa, including Odonata (Hickling et al. 2005), Orthoptera, aquatic bugs and certain beetle families (Hickling et al. 2006). In some of these groups, the extent of the shift has even exceeded that of butterflies.

The first obvious question concerns how individual species will respond to a warming climate. Warren et al. (2001) have drawn attention to the fact that an individual species' ability to respond by tracking its 'climate envelope' (the geographical area defined by the range of climatic conditions in which a species can persist) will depend upon its propensity to disperse, its degree of habitat specificity and the large-scale distribution of the preferred habitat within the wider landscape. Thus, widespread habitat generalists that disperse readily will have relatively little difficulty in responding to warmer temperatures by simply moving polewards. However, at the other extreme, species with limited powers of dispersal, that are habitat specialists and where those habitats have become highly fragmented are trebly disadvantaged and so will have great difficulty in tracking the changing climate. An example is the Silver-studded Blue, *Plebejus argus*, a species with very exacting requirements on habitats that are themselves highly fragmented in the modern landscape (mainly lowland heathland but also chalk grassland and sand dune). On top of this, the adult butterflies are extremely sedentary, forming small and substantially closed local populations. Consequently, this species has very limited potential to respond to climate warming by shifting its distribution and has therefore undergone a substantial decline in range within Britain over the last 100 years (Asher et al. 2001).

Due to their small size, insects respond to changes in micro-climate as much as, if not more than, to larger scale changes in the macro-climate. Lessons from the detailed research on the Large Blue butterfly, *Maculinea arion*, and related species in the same genus have shown the vital significance of micro-climate and how it affects the ants on which the butterfly depends (Thomas et al. 2009). Temperature and other micro-climate factors can vary substantially over short distances in response to microtopography and, especially, vegetation structure (Geiger 1955; Stoutjesdijk and Barkman 1992). It follows that management operations, for example the imposition of grazing or mowing in grasslands, can have profound impacts on the microclimate and thence the invertebrates that can live in the habitat. Thus, for example in grasslands, future projected increases in regional temperatures could be offset by changes to the microclimate achieved through adjustments to the management of habitat structure. Similarly, the creation of greater microtopographic variation within a grassland habitat to generate a variety of slopes with different aspects would provide insects with temperature refuges, at least in the short term. Although the early habitat, management literature emphasised this point (Fry and Lonsdale 1991; Kirby 1992), not enough attention has yet been given to this simple principle of site management for invertebrates, perhaps because conservationists concerned with groups other than insects have traditionally not been used to thinking about habitats at this micro-scale. Although this approach is unlikely to provide a long-term solution to temperature rise, it may nevertheless buy some extra time in the short- to medium-term in which insect populations can either adjust to the new conditions or move to new locations (Settele and Kuhn 2009). Topographic heterogeneity at larger scales may also confer some insurance against climate variability through the provision of a variety of microclimates (Oliver et al. 2010).

One complication to this picture is that concurrent changes in microclimate and macroclimate may not be tightly correlated in magnitude or even in direction. WallisDeVries and van Swaay (2006) have suggested that higher temperatures induced by global warming combined with increased atmospheric nitrogen deposition could promote more luxuriant vegetation growth, which may actually produce a cooling effect for species that reside close to the ground. They suggest that this will particularly affect butterflies that overwinter as eggs or larvae, for which early spring temperatures are especially critical.

Species do not respond in isolation to changes in the climate. They are influenced also by interactions with other species. For insects, these could include competitors, mutualist partners, food plants and natural enemies, any of which could respond differently to the same change in the climate. The resultant disruption to trophic and other inter-specific relationships could have profound effects on the ability of a species to track its climatic envelope. Insects typically have short generation times, so may be restricted by a dependency on much longer-lived food plants (Pelini et al. 2010). Likewise, if the climate envelopes of an insect herbivore and its host plant, determined by separate physiological constraints, do not move in geographical synchrony, the insect will be unable to occupy parts of its new potential range because the host plant is absent (Schweiger et al. 2008). Similar disruptions to inter-specific interactions have been reported or are predicted as a consequence of differential changes in seasonal phenology (Both et al. 2009; Memmott et al. 2007). Singer and Parmesan (2010) even suggest that such a phenological mismatch was instrumental in the extinction of a metapopulation of the rare Edith's Checkerspot butterfly, *Euphydryas editha*, in California.

A more philosophical question, but one with practical implications, concerns how we should regard shifts in the distributions of species that result from climate change. Based on an offshore island with a comparatively depauperate insect fauna compared to the adjacent continental land mass, British conservationists take a keen interest in which species are successfully colonising our shores. There is plenty of evidence that the composition of many groups within the British insect fauna is changing fast with many new species arriving from the near continent (MacLean 2010). There is a tacit assumption that native species have more right to command conservationists' attention and resources than others that do not have a continuous history of occupation. However, awkward questions start to emerge, such as what exactly is the meaning of 'native' in the context of climate change? Can we justify expending scarce resources on conserving species which are at the northern edge of their range in Britain but which are widespread and common in the rest of Europe and which may become more common in Britain as the climate warms?

Altitudinal range shifts in response to climate change have received much less attention than latitudinal ones (Merrill et al. 2008). High altitude insect species may turn out to be some of the most vulnerable, because the movement of species distributions towards higher elevations will progressively isolate populations and make eventual escape to other mountain peaks even more unlikely. Likewise, processes operating at 'warm' margins may be very different to those at 'cool' ones; in Britain, the ranges of northern species are predicted to decline more severely than southern ones (Hill et al. 2002). There is a need to understand better what processes are operating at all types of range margin, and the extent to which these differ depending on whether the margins are warm or cool, latitudinal or altitudinal.

18.3 Assisted Colonisation

As climate-driven changes begin to take effect on insect distributions, there will be a need to consider how we react to species that get 'left behind', whether as a result of poor dispersal ability, extreme habitat specificity, insufficient habitat connectivity to allow natural movement and colonisation of newly available habitat patches, or all of these in combination. One intervention option in response to this problem that is rapidly gaining support is to take individuals from an existing population in order to found new populations elsewhere. It is useful at this point to be clear about definitions. Translocation refers simply to moving individuals, populations or communities to new sites, whether or not these sites have any history of being occupied by the species concerned. Reintroduction refers specifically to an attempt to re-establish a species at a location from which it has disappeared. JCCBI (1986) and Invertebrate Link (2010) provide further detail and an interesting insight into how the thinking on this topic has changed over the intervening 25 years (see also Morris and Cheesman, Chap. 2). Insects are often seen as suitable subjects for such translocations, given the relatively straightforward logistics of capturing, moving and releasing individuals and their theoretical capacity for rapid population increase once established at a new location. Whether or not this claim is justified, there is little doubt that this approach will gain in popularity, exercised with official endorsement or otherwise.

There has long been a view that, whilst reintroductions are acceptable, even welcomed as a way of restoring damaged ecosystems, deliberate introduction of a species into a new location where it has never occurred before is to be discouraged.

However, there is a case for arguing that, against a background of climate change, such proactive interventions may indeed be essential to help species track their climate envelopes as these move into new geographical areas in which species have no history of occupation. The term for deliberate introduction of species into new locations outside their historical ranges is “assisted colonisation”. Current opinion amongst conservationists is sharply divided about the wisdom of this approach (Hoegh-Guldberg et al. 2008; Ricciardi and Simberloff 2009; Sandler 2009; Stone 2010); there is urgent need for guidelines on what is appropriate in different circumstances. A recent experiment that translocated two common butterfly species approximately 35–65 km beyond their existing northern (cool) range margins in Britain, but within their modelled new climate envelopes, demonstrated the feasibility of this approach (Willis et al. 2010). Indeed, Thomas (2011) has argued for a far more radical approach, whereby translocations are used as a way of rescuing endemic species that are most vulnerable to extinction driven by climatic change. As a further extension of the idea of assisted colonisation, it has even been suggested that conservationists should consider the construction of completely new communities using species that may have had no prior ecological interaction (Seddon 2010).

Such restoration approaches will also become increasingly important as more sites are destroyed through conversion to alternative land uses or degraded as a result of inappropriate or lack of management. However, there are several issues to consider before adopting this approach too uncritically. Firstly, apparent success in translocating species to new sites easily becomes a double-edged sword: demonstrating that local populations can be saved from extinction by simply moving them elsewhere could indirectly jeopardise all other populations in future if planners and developers came to regard translocation as a way of dealing with a population of a protected species that obstructs a development plan, as opposed to a solution of last resort to rescue a population from imminent destruction. Secondly, very few (re)introduction attempts have been carefully monitored over a reasonable length of time to see if a sustainable population really does become established. Of course, this in turn raises questions of what is meant by sustainable. For how long? With what probability of survival? In any case, monitoring before, during and after translocation, of both the donor and recipient populations, should become an essential requirement of any programme. Thirdly, (re)introduction/translocation success should not be judged solely on the basis of establishing a sustainable insect population; interactions with other organisms, especially natural enemies, need to be considered too (Henson et al. 2009). Likewise, when attempting the translocation or re-creation of whole habitats containing important insect communities, due consideration should be given to ascertaining whether the important ecosystem processes and services provided by insects, such as pollination, have been reinstated as well as the target species (e.g. Forup et al. 2008). Too many habitat restoration projects do not extend beyond considering whether the plant community has been established, to see if invertebrate assemblages have been restored, let alone if all pollinator, natural enemy and decomposer interactions are functioning.

18.4 Invasive Alien Species (IAS)

Invasive alien species, namely those species that have been introduced outside their indigenous range by human activity and whose ecological traits (rates of growth, reproduction and dispersal) are such that they threaten native biota, either deliberately or otherwise, are widely regarded as presenting the second most serious threat to global biodiversity, after habitat destruction. Human activity, deliberate or otherwise, is often responsible or implicated in such situations, and previously innocuous species can become invasive as a result of climate change. Unlike degradation, over-exploitation or even complete loss of habitat, infiltration of IAS into new ecosystems cannot easily be reversed once they have become established. Insects themselves can have significant and far-reaching impacts on recipient communities, with effects sometimes cascading through trophic levels. In general, problems with non-indigenous insects arise when they are introduced into, or simply arrive in, new geographical areas in advance of, and therefore out of control of, their natural enemies.

The Harlequin ladybird, *Harmonia axyridis*, a native of Asia, has a record of severe impacts on the native coccinellid fauna of geographical regions that it has invaded (Koch 2003). Its comparatively recent spread through Europe, including arrival in Britain (Brown et al. 2008), is causing considerable concern although opinions differ on how severe the impacts will ultimately be. An environmental risk assessment (van Lenteren et al. 2008) showed that this species poses a very real threat to native biota, including species of conservation concern (Ware and Majerus 2008). It is worth emphasising that previous experience with this species in America had already demonstrated the dangers that it presented and yet its deliberate introduction into Europe for biocontrol purposes went ahead anyway. It is clear that, even after knowing for more than a hundred years that biocontrol programmes can have devastating unintentional side-effects, tighter controls on the release of biocontrol agents are still needed.

Ants have probably received the most attention as IAS because their vast numbers can produce such strong effects, both through direct competitive and predatory interactions with other insects and indirectly through their effects on other taxa. Invasion by the Argentine ant, *Linepithema humile*, for example has been shown to dissemble whole communities of other invertebrates (Sanders et al. 2003) and to have profound effects on important ecosystem processes such as pollination (Lach 2008) and seed dispersal (Rodriguez-Cabal et al. 2009) with knock-on effects on plant community composition (Christian 2001). This ant species has very considerably extended its range in the recent past, a trend that continues.

When considering how IAS may impact adversely on the interests of insect conservation, it is worth remembering that it is not always other insects that are the cause of the problem. Invasive plants can modify the species composition of the communities that they infiltrate to the detriment or even exclusion of species that are important host plants for insects, or they can radically alter the physical structure and microclimate of the habitat for insects. Likewise, vertebrate herbivores can transform the suitability of habitats for insects through their grazing and browsing activities.

18.5 Introduced and Domesticated Species

A small number of insect species, principally amongst the Apidae, have been introduced into new regions of the world where they have been to a greater or lesser extent domesticated to enhance pollination services. These are mainly the honeybee, *Apis mellifera*, and various bumblebees in the genus *Bombus*. In some instances, there is circumstantial evidence that populations of native pollinators have diminished since the arrival of introduced species (Goulson 2003; Stout et al. 2003) although it is extremely difficult to test for population-level effects with such mobile organisms. Nevertheless, given the sheer size of the average honeybee colony (a typical hive contains up to 80,000 workers), it is hard to believe that this will not generate severe resource competition with native pollinators, even if only locally. Negative correlations between the presence of honeybees and bumblebee abundance (Forup and Memmott 2005) and performance (Goulson and Sparrow 2009) suggest that honeybees may be having an effect. The limited experimental evidence supports this conclusion (Thomson 2004, 2006), but the exact mechanisms involved are elusive. By extension, effects on the diversity of smaller pollinating insects are likely to be even greater.

In spite of widespread concern over 'Colony Collapse Disorder' that has resulted in dramatic declines in the number of honeybee colonies in Europe and America, beekeeping is gaining popularity as an amateur pastime in Britain. Location of honeybee hives is currently unregulated, leaving the obvious danger that they are placed within or near nature reserves or close to the nest sites of rare pollinator species that might be adversely impacted.

18.6 Ecosystem Services

Insects provide a number of important 'ecosystem services', the most significant of which are pollination, decomposition and the natural control of potentially serious pest insects and weeds through herbivory, predation and parasitism. There is now a much greater recognition of, and indeed political emphasis on, how these and other ecosystem services are provided by biodiversity. A documented decline in the diversity of bee pollinators, although not hoverflies, replicated concurrently across Britain and The Netherlands (Biesmeijer et al. 2006) has drawn attention to the fact that the widely claimed current 'pollination crisis' (although see Ghazoul 2005 for a counter-argument) is not confined to domesticated pollinators. Precise reasons for this are unclear and the subject of much debate, but the most plausible explanation is a general 'agricultural intensification' of the countryside, including the loss of flower-rich meadows, the draining of wetlands and the loss or degradation of interconnecting habitats such as hedges and uncultivated field margins. There is a broad consensus that habitat loss and the decline in abundance of nectar-rich flowers are almost certainly responsible for the catastrophic declines in several of the 25 native bumblebees in Britain (Goulson 2010): three species have gone extinct in the last 70 years and a further seven species have declined sufficiently to be designated as ‘priority species’ on the national biodiversity action plan.

One positive indication that these matters are being treated seriously by environmental policy-makers is the UK Government’s recent commitment of £11M to a research initiative to investigate pollinator declines. A more general appreciation of the other important free services that insects provide would be a welcome development.

18.7 Increasing Public Engagement

Perhaps prompted by increasing general awareness of global environmental challenges, there is now a much wider appreciation amongst the public of the significance of biodiversity (a word that was added to the conservationists’ lexicon only in the late 1980s) and the importance of preserving it. The extent to which ‘armchair concern’ gets translated into more effective participation is of course another matter, but the signs are encouraging. More people are engaged in environmental issues than ever before and some of this interest is being channelled into natural history and the quest for more information about species. An increasing interest in, and valuing of, insects is one by-product of this development, although we should remember that significant disparities in this respect remain between temperate northern hemisphere countries on the one hand and southern hemisphere and tropical countries on the other. People and governments in the latter countries understandably have tended to be more concerned with how insects impact on human health and food production. Consequently, attitudes towards the conservation of insects in these countries still lag somewhat behind those in northern hemisphere counterparts, although their insect communities are generally considerably more species-rich (Stewart and New 2007).

Britain has been blessed with a long tradition of natural history recording. In spite of warnings of a decline in basic natural history, an ageing population of experts and an increasing dissociation of certain sections of society from the natural environment (Cheesman and Key 2007), elements of which are certainly true, there are many encouraging signs that interest in insects is growing rather than shrinking. A series of Invertebrate Link conferences from 1997 to 2006 did much to raise awareness of the importance of fostering the next generation of field entomologists (Masters et al. 2007). Three reports on the state of taxonomy by the House of Lords Select Committee on Science and Technology, and a subsequent one by the Linnean Society, have called for greater investment in taxonomy to underpin ecology and conservation. The list of field guides and taxonomic keys continues to expand, particularly those aimed at encouraging the novice, together with general natural history accounts of particular groups and distribution atlases. The increasing popularity of the more charismatic insect groups has spawned a number of highly successful membership organisations devoted to taxonomically narrowly-focused groups: Butterfly Conservation (also covering macro-moths: Warren, Chap. 6), British Dragonfly Society, Bumblebee Conservation Trust. Buglife – The Invertebrate Conservation Trust (Stubbs and Shardlow, Chap. 4) now champions the cause of insects and other invertebrates in Britain and also over an increasingly wide geographical canvas.

Modern technological advances can claim much of the credit for this expanding engagement by non-professionals. The vastly improved mass communication provided by the internet, including access to some excellent online resources for species identification, such as photo galleries, facilities for individuals to capture and organise large amounts of natural history information and images digitally, and the development of specialist e-groups have all helped to engage a wider audience, especially the more technologically literate younger generation. The advent of comparatively inexpensive high quality digital photography has opened up the world of insects to many people who might otherwise not have engaged with natural history at all. The Open Air Laboratory (OPAL) network (http://www.opalexplorenature.org/) currently promotes public engagement in natural history by encouraging people to explore, record and protect nature in their local areas. New facilities for on-line recording allow for rapid assimilation of data into national recording schemes and feedback to contributors. For example, the Open University's iSpot facility (http://www.ispot.org.uk/) is an online community of natural history enthusiasts that aims to provide a bridge between experts and novices. Participants submit digital photographs for expert identification, identification and are encouraged to build up their own reputations by correctly identifying other people's submissions. Feedback from the experts enables them to see immediately see how their contribution fits into a wider body of information about a particular species. All of these data can be fed into the UK National Biodiversity Network's 'Gateway' (http://data.nbn.org.uk) that provides a central data warehouse to provide users with immediate and open access to distributional information about species. All of these developments bode well for engaging a wider public with the value of insect conservation.

Some concerns have been expressed that such developments will result in a lowering of the standard of natural history recording; Morris (2010) for example reports a decline in the proportion of records submitted to the UK Hoverfly Recording Scheme that refer to species which are more challenging to identify. Offset against this however is a generally expanding population of amateur enthusiasts engaged in activities ranging from basic biological recording to long-term monitoring and individual species conservation.

Another potential danger with greater public engagement may be an increase in support for the anti-collecting lobby. Whilst most insect conservation biologists agree that responsible collecting of the non-charismatic groups provides essential information on which to base conservation strategies and decisions, an increasingly vociferous minority argues that widely accessible modern digital photography should replace voucher specimens. A code of conduct (Invertebrate Link 2002) has been published which is fully supported by the main UK conservation organisations, but the issue remains sensitive.

18.8 Widening Approaches

The species focused approach to insect conservation has produced some notable successes in terms of restoring the fortunes of individual species and re-establishing others after local extinction. Valuable lessons have been learnt from these exercises in terms of the various factors which determine population persistence, that have wider relevance and can inform conservation strategies for other species. However, with the exception of a few high profile species, the single species approach is increasingly untenable. There are simply too many species to deal with each one individually, and in many cases there is too little information about their precise habitat requirements to inform what actions are required to help them without considerable investment in new research. Conservationists need to work at higher levels of ecological organisation to achieve maximal conservation gain from inevitably limited funds.

A habitat-based approach may seem like the obvious alternative, but insect conservationists remember only too well how the old adage that, if you look after the habitat the invertebrates will follow, inadvertently led to the loss of many important insect species from apparently well managed sites. Many insects have very specialised, and often very small scale, habitat requirements that can easily get overlooked by more general habitat approaches. Likewise, at the initial assessment stage, sites that hold little interest for other taxonomic groups may nevertheless contain habitat features of great significance to insects and other invertebrates such as dead wood, bare ground and wet seepages. Some attempts have been made to incorporate these considerations into the preliminary site evaluation process (Webb and Lott 2004) in a way that can be utilised by non-entomologists.

A further extension of such approaches is the development of indicator taxa as surrogates for other species, habitat features or ecosystem processes that would otherwise be prohibitively time consuming or expensive to measure directly (McGeoch 1998). These attributes include wider taxonomic groupings, measures of habitat quality or integrity, responses to perturbation, measures of restoration success, or particular ecosystem processes. Much energy has been expended testing for ideal candidates, with mixed success. Frequently, a lack of congruence between taxonomic groups, for example in terms of geographical distributions (Prendergast et al. 1993) or responses to processes of interest (Painter 1999), suggests that conclusions drawn from such short cuts might be unreliable. Furthermore, the taxa with the greatest public appeal and support may not necessarily be the most appropriate surrogates for wider biodiversity. Unfortunately, considerable terminological confusion is evident in the literature over different concepts of surrogacy, including indicator species, umbrella species, flagship species and keystone species (Fleishman and Murphy 2009). Nevertheless, the need for scientifically reliable indicators is undeniable.

Two practical applications of the concept require further development. First, what individual species or groups of species can be used to assess habitat quality or value of a site for insects? Specific solutions will obviously vary between habitat types, and considerable progress has been made for some of them (Foster and Eyre 1992; Fowles et al. 1999), but more are needed. Second, how can insects be used to indicate wider environmental attributes such as ecosystem health or integrity? It is noticeable that the use of farmland birds in Britain as national indicators of environmental quality, even being used by the UK Government as one of several indicators contributing to a national index of sustainable development, has indirectly driven the development of strategic agri-environment initiatives. Given the evidence that insects have declined more significantly than birds in Britain (Thomas et al. 2004) and their more rapid response to environmental changes, there is a strong argument for inclusion of insects in such indices.

Nature conservationists in Britain are now starting to adopt an even broader-scale approach, increasingly focusing their efforts at the level of whole landscapes in recognition of the realisation that this is the scale at which many species operate. Ironically, this is the scale at which many non-European countries started their insect conservation endeavours, never having had the luxury of being able to adopt the single-species approach. The emphasis is on building and enhancing 'ecological networks', suites of high quality sites that are functionally connected by species moving between them and that operate as dispersed but coherent units (Lawton et al. 2010). The approach employs a lexicon of terms that have been in the ecological literature for many years but which have only recently gained currency in practical conservation: wildlife corridors, connectivity, stepping stones, buffer zones, landscape permeability. There are several reasons to be optimistic that this approach will benefit the conservation of insects. First, it is now realised that some species require substantially larger areas than was previously thought, and certainly larger than existing single sites. Thus, attempts to reintroduce the Large Copper, *Lycaena dispar*, were suspended because it was realized that no single site has a sufficiently extensive block of fenland habitat (Asher et al. 2001), something that The Great Fen Project (the creation of 3,700 ha of wetland that will join two existing National Nature Reserves in eastern England) is intended to rectify. Second, detailed research has confirmed that the long-term persistence of many species is dependent upon some form of meta-population structure, in which separate habitat patches are occupied by local populations that can periodically go extinct but nevertheless be recolonised by individuals dispersing from other habitat patches. In such cases, long-term persistence is dependent upon dispersal between habitat patches and therefore the degree of connectivity between them. Thirdly, it is intended that wildlife corridors will enable species to respond to climate change by moving to other, perhaps newly created, sites as currently occupied ones become unsuitable for them. There is growing evidence that insects use corridors to disperse between sites (e.g. Gilbert-Norton et al. 2010; Pryke and Samways 2001), in addition to their value as linear strips of suitable habitat.

18.9 Future Opportunities and Imperatives

At least in Britain, insect conservation has come a long way since the early days of attempting to protect single species on isolated nature reserves. Much has been achieved in practical conservation terms and important lessons have been learnt that have much wider application than for just the system under study at the time. Future conservationists will need to embrace and exploit new enabling technologies as they emerge. We are entering a new bioinformatics era in which mind-boggling amounts of information will be available for analysis, especially at the molecular level. The ability to sequence the whole genome of a species will become routine because it will be both rapid and cheap. Technologies are already emerging for the rapid sequencing of whole communities. This will open up many new possibilities for tackling the fundamentally ecological questions that underpin conservation management. It may also prompt a paradigm shift in conservation objectives: after years of treating the species as the focal unit for conservation, the priority may become the conservation of genes in populations.

At a more prosaic level, as we enter an era of potentially rapid environmental change, it will be essential to maintain long-term monitoring activities, both to follow the progress of changes that are already underway as well as to detect new pressures as they emerge. Insects, with their sensitivity and rapid response times, will continue to be essential sentinels for environmental and habitat change; the challenge for insect conservation biologists will be to select which species or groups of species do this job with the greatest precision and reliability. Long-term monitoring is difficult to sustain when finances are tight, priorities change and benefits accrue only slowly. However, it is worth remembering that two of the longest-running insect monitoring schemes started out with rather different objectives to those which they have today. The Butterfly Monitoring Scheme was initiated to detect impacts of the widespread use of insecticides (Pollard and Yates 1993), whilst the initial objective of the Rothamsted light trap network was to study the spatial distribution and temporal dynamics of moths (Taylor 1989). Both schemes have since been harnessed for monitoring much wider environmental change and have provided some of the most convincing evidence for widespread impacts. It is very likely that the catastrophic declines in certain butterfly and moth species in Britain (Conrad et al. 2006; Fox et al. 2006) have been accompanied by similarly sharp declines in other less well studied insect taxa, but we currently lack the evidence for this. There is therefore an urgent need to initiate monitoring schemes that cover a broader range of insect groups to test the criticism (Hambler and Speight 2004; but see response by Thomas and Clarke 2004) that butterflies may not reflect what has happened to other taxa.

Insects live in complex ecological webs, connected with a variety of other taxa. Declines in certain insect groups such as moths must inevitably have knock-on effects on their predators including birds and bats. Insect conservationists should emphasise these links to strengthen alliances with organisations representing these high-profile popular groups. Likewise, greater emphasis should be placed on the vital role that many insects play in important ecosystem services such as pollination and pest control. For the immediate future, in Britain at least, the emphasis will have to be on halting and reversing the declines that have characterised the last 50–100 years for so many insect groups. Insect conservation biologists will have to engage in restoration of species and habitats as well as the more familiar preservation of existing ones. They will also need to expand their horizons to landscape-scale projects, often involving multiple stakeholders. These will be significant challenges but, with growing public support and an expanding scientific evidence base, insect conservation has a bright future.

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Chapter 19
Developing Insect Conservation: Concluding Thoughts

Tim R. New

Insect conservation is now accepted widely as a major need in considering Earth's biodiversity, and the preceding chapters have summarised some of the major steps by which the discipline has gradually been fostered and become 'respectable' on conservation agendas through both regulatory (more widely, political) recognition and scientific worth, and through the dedicated guidance of individuals committed to the belief that the enterprise is worthwhile, even vital. Both ethical and practical grounds for conservation have gained wide acknowledgement, and policy has matured in parallel to accept insects (and other invertebrates), albeit in some cases reluctantly, in considerations of 'biodiversity'. Whilst practical conservation is based, as far as possible, on sound biological understanding, and effective advocacy to gain public/community sympathy, much insect conservation has its origins in scenarios of very limited knowledge and unsympathetic perception of its worth. Many insects targeted for conservation have little tangible or practical value to people, other than idealistic wishes to prevent their extinction or declines, as part of our biotic heritage – and in some instances countered by advocacy to eradicate 'bugs' as pests, still the more common public image of insects in general. Campaigns for most species selected as conservation targets have been fostered through the zeal of single or few advocates, and the species are – almost by definition – rare and difficult to study quantitatively. Management has necessarily been initiated without detailed autecological knowledge of many of the species targeted, and refined by 'on the job' experiences as the conservation programmes develop and are refined. Much of the later development has served, progressively, to consolidate the initial templates for action, reduce the risks involved from management actions, and so increase confidence in the measures taken. And much of the wider progress in insect conservation has been driven by economic concerns and drawn on experiences from

T.R. New (✉)
Department of Zoology, La Trobe University,
Melbourne 3086, Victoria, Australia
e-mail: t.new@latrobe.edu.au

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pest management, with the practical outcomes having serious economic consequences for humankind.

Understanding insect biology as a basis for informed and adaptive management has the rather distinct strands of 'basic' and 'applied' genesis, with conservation practice developing by drawing on both of these fields. Thus, pest management in cropping, pastoral and forestry arenas has provided much of the most detailed information on how insect populations 'work', and is progressively being integrated with wider environmental considerations that incorporate cultural controls and practices far less damaging than some of those more widespread in the past. Conservation considerations include, as examples, reduction of pesticide non-target effects and greater considerations of the safety of classical biological control agents: both of these represent important changes in philosophy of pest management, with the drivers including needs to consider landscape level effects and wider conservation issues, including the wellbeing of native communities and of any threatened insects known in the regions of treatment. Following from Howarth's (1983, 1991) classic commentary on non-target effects of introduced biological control agents, with implication of their widespread involvement in losses of endemic native insects, considerable – sometimes highly emotional – debate has ensued on this practice, and continues (Barratt et al. 2010), with central relevance to conservation of insects. Many localised endemic insects can occur within the dispersal range and evolutionary potential for differentiation of introduced predators and parasitoids (New 2009) which are part of the alien faunal component viewed widely as threats to native species. Other forms of biological control, particularly so-called neoclassical biological control (in which the introduced agents have had no historical association with the target pests, so that their establishment is founded on new ecological associations, in itself evidence of flexibility and, perhaps, potential to further spread their influence into new communities), are also viewed with grave concern by conservationists. Emphasis on conservation biological control avoids the complications of alien species introductions, by employing only native natural enemies, but massive buildup of numbers or concentrations might still need to be considered if they are close to known populations of threatened insects that could be vulnerable – for example, by being phylogenetically related to the target species.

The many parallels between conservation biological control and conservation of threatened species were discussed by Letourneau (1998). Both involve preventing extinction and sustaining viable populations and ecological functions, and the manipulations of habitat and critical resources needed to assure this. In essence, the different priorities of primary producers and conservation biologists draw on the same background aims and practices, and shared experiences of how to benefit the desired populations and counter threats to them. A major conservation concern has been the decline of pollinating insects, with this major ecological process critical to primary production and safeguarding human food supplies compromised by losses of bees, in particular. Restoration of pollinator activity is receiving continuing attention.

Within the classical biological control arena, small isolated endemic faunas of major conservation concern have proved particularly susceptible to invasions (islands: Howarth and Gagné, Chap. 16), but elimination of aliens from such small areas may be practicable, as for rats on some New Zealand islands now important reserves for weta (Watts et al., Chap. 10).

Much of the foundation of insect conservation was based on concern over declines of single species, most notably butterflies sought by collectors and some assuming increased value as they became scarce and more difficult to obtain. And, although habitat changes have been the primary agent of decline, accusation over a century and more that overcollecting contributed to species losses has markedly offset the contributions that hobbyists have made to fundamental knowledge of the insects, and their widespread concerns for their conservation. That conservation must be based on site security, and progressive steps to reserve or otherwise protect critical sites have been augmented in some case by translocations or re-introductions of selected species to new sites or to historically-occupied sited from which they have been lost. Some re-introductions of butterflies, paramount the Large Copper (*Lycaena dispar*) and Large Blue (*Maculinea arion*) to Britain, are amongst the all-time classics of this aspect of insect species conservation, and both demonstrate the intricate biological understanding needed for success. *L. dispar*, for example, had been the subject of reintroduction attempts for many decades, without the realisation that the selected site might not be sufficiently large to support a permanent population (Pullin et al. 1995). *M. arion* became extinct in England just as intensive study around that time clarified the aspects of its biology that might have saved it (Thomas 1995), but that knowledge has since then assured that it has been reestablished successfully in the British resident fauna.

The taxonomic variety of species that have become flagships used to stimulate development of conservation interest is much wider than butterflies; it is paralleled by weta in New Zealand, for example, and the Delhi Sands fly, the Lord Howe Island stick insect, and the elephant dung beetle are amongst the many other examples noted in earlier chapters. The progressive outcomes have been the listing of individual species of many insect groups as of conservation concern, with criteria, details and formal obligations of regulation or legislation differing widely – but with the number inevitably representing only a small proportion of the species needing such attention, and the practical wisdom of increasing such lists (either legislative or advisory) to be more representative debated. However, almost all such protection includes a prohibition on (or very strict control of) 'take' of specimens. Well-intentioned in most cases, this condition is based on the supposition that removal of specimens ('take' in any of the senses defined by ESA, for example: Black, Chap. 8) is a threat to the species. In many instances it is unlikely to be so, particularly in relation to losses resulting from habitat changes but, in the case of tiny isolated populations already reduced through other factors, might indeed tip them 'over the brink' to extinction or increase chances of their stochastic loss. The outcome of such prohibitions has in many places been to deter the interests of hobbyists, so that the wisdom of taking this step without solid justification of likely harm is controversial and has sometimes led to loss of credibility, and alienation of the constituency whose aid is most critical in conservation. One consequence has been to reduce the amount and dissemination of basic information accumulating on biology, distribution and conservation need, because hobbyists in many instances have either ‘gone underground’ or sought alternative recreational pursuits. Particularly for butterflies and some families of beetles, formal prohibition of collecting can increase desirability to collectors and lead to black market operations with specimens sold at highly inflated prices. Debate will assuredly continue.

The needs to understand the habitat of insects targeted for conservation, in terms of critical resources, have become increasingly prominent in guiding management – with Dennis et al.’s (2006, 2007, see also Dennis 2010) discussions of these meriting considerable attention in demonstrating the great variety of these. Insect conservationists, and others, increasingly acknowledge that ‘habitat’ is not simply a place to live, but a juxtaposition of the critical resources needed by the species. Most insect species conservation plans have traditionally emphasised the roles of ‘consumable’ resources, as those most easily defined and manipulated, so that provision of larval food plants, and nectar plants (for Lepidoptera) or prey have dominated habitat restoration and management. Considerations of the ‘utilities’ suite of resources, some reasonably clear from observations of behaviour and distribution but others less defined, have lagged considerably.

In parallel, considerations of population structure have become more central, linked with the needs for wider landscape conservation. The revelations of metapopulation studies on butterflies over recent decades have changed perspective of the significance of many local extinctions of populations that were previously presumed to be closed. Integrating considerations of resource distribution and dynamics with those of population structure and landscape influences on connectivity, and planning for future influences of climate change imposes enormous challenges for conservation. Those considerations will demand considerable skills both to anticipate, and to manage. Climate change has rapidly entered the portfolio of threats to many geographically restricted species but, whereas some aspects of distributional change driven by this may be broadly anticipated, the future spatial co-occurrence and temporal synchronisation of the species and consumable resources likely to be affected differently by change are far more difficult to assess. Likewise, changes in local community structure as species move (or are driven) from their current ranges are almost wholly speculative, but resultant new interactions suggest that some ecological specialists, at least, may become more intensively threatened. In most cases, our current knowledge is insufficient as a template against which to assess changes in the future.

Many recent cases of insect species conservation have revealed that the resources available to prosecute management plans effectively are grossly inadequate: the other side of the coin to there being ‘too many species to deal with’. Government or agency support, be it of expertise or funds, has most commonly been allocated on a triage basis – with debate continuing over the most worthy criteria to adopt, but risk of extinction without such attention ranking highly. Calls for improved design of insect species recovery or management plans (New 2009) go hand-in-hand with needs for vastly improved advocacy and education to gain support for insect conservation. Such support is still lacking over much of the world, as an understandably low priority in relation to more pressing human needs: and conserving insects without any short term or tangible gains to the local populace is seen widely as impracticable. Incorporating selected species into wider conservation agendas, as attempted for the world's largest butterfly (*Ornithoptera alexandrae*) in Papua New Guinea (New 2007, for summary) will commonly depend on perceptions of local benefits. Such measures depend critically on local support rather than being imposed by dictum of expatriate 'experts', sometimes historically without any practical knowledge of the scenarios they attempt to influence. Whatever the taxa, or the scale of conservation need, sustained sympathetic and informed participation from the local constituency is a major key to success, and is enhanced by wider national or international recognition of the importance of the project's target species or biotope. 'Friends' Groups' and similar focused support groups for individual species or projects are largely taken for granted in more affluent countries, and the organisational strengths and influences of larger bodies such as the Xerces Society (Pyle, Chap. 7) and Butterfly Conservation (Warren, Chap. 6) major catalysts to interest. Elsewhere, for south east Asian Lepidoptera for example, the 'Hong Kong Declaration' (2007) goes some way toward filling equivalent need, and cultural differences may also be important – the 'Osaka Statement' (1996) from Japan is another such case of local good intention, with such 'bottom-up' processes a major component of the process of successful insect conservation. The major problem is translating such resolutions from idealism to action. Almost any such endeavour depends, at least initially, on the zeal, tact and organisational skills of committed individuals, and it is impossible to overstate the importance of such individuals in foundation of several of the key organisations and support groups highlighted in this book. Conservation groups or sections within national entomological societies are gradually gaining more prominence.

Limitations of the species level approach necessitate complementary considerations of wider perspectives, inevitably sacrificing some of the detail that is the core of individual species conservation but emphasising guilds, assemblages, communities and biotopes at scales from local sites to broad landscapes. In parallel, exploring ways of integrating insect conservation with wider efforts will also continue, but increasingly with realisation that such umbrella efforts are by no means 'automatic'. Presumptions of effective surrogacy are often unfounded, and management of areas for, as examples, large cats or primates do not guarantee survival of all the species of specialised insects and other invertebrates within those areas, as Haslett (Chap. 14) has also stressed. Visionary planning for networks of conserved habitats for the widest possible biodiversity benefits (Samways 2007) and to sustain or re-establish connectivity within landscapes merit the strongest possible support. The broadening of planning needed, now stimulated increasingly by the ramifications of climate change on distribution patterns, remains difficult, not least because of the intangibility of benefits to many people in areas where this approach is badly needed and is perhaps the only real option for practical conservation to occur.

Perhaps the greatest accompanying need is for enhanced efforts to survey ('inventory') insects and to monitor selected groups within a series of major biotopes and protected areas – simply 'locking up' areas, without appreciating needs for management to, for example, regenerate early successional stages or particular vegetation associations accomplishes only part of the task of conservation, and insects are instrumental in furnishing the information needed for much effective management. Many of the species noted in this book illustrate well their interdependence with resources that are naturally susceptible to change, and which will almost certainly disappear without such focused attention. The balance for the future is to attempt to assure that as much variety as possible is retained or regenerated in efforts to reduce extinction rates and lessen numbers and rates of losses of the habitats that support insect diversity. Calls for increased taxonomic expertise and understanding recur in this book, but insect conservation must proceed without complete knowledge of identity, richness, distribution and biology of most of the organisms involved.

Many of the major causes of insect species losses, broadly 'threats', have become well-understood, but their compounded influences are difficult to quantify. Rather few insect species extinctions have been documented firmly over the last century (Mawdsley and Stork 1995; Dunn 2005), and are presumed widely to vastly understate reality, with numbers and rates of extinctions increasing and forecast to increase further, particularly amongst poorly documented tropical faunas. Protection of remaining natural habitats, as above, is the most important counter to this, with the reservoir communities present – even if impoverished – the only signposts for future diversity likely to withstand human onslaught. Attempts to document tropical insect faunas along the lines suggested by Janzen (1997) for Costa Rica are infrequent, but habitats such as 'totem forests' in West Africa and maintained largely free from human interference (Larsen 1995) are unique sanctuaries for endemic insects, and others. The general global aim of assessing and conserving 'hotspots', complemented by a fully representative and comprehensive suite of more local reserves, and including assessment of selected ecologically informative insect groups on those considerations, could do much to firm the template for future priority. Without such broad measures, further losses seem inevitable. Likewise, emphasising the importance of sustainability of supply of insects exploited by people is a message easy to understand, if not always to transfer to practice – but is also one with much wider ecological relevance.

This book has summarised some of the ways in which insect conservation has made the transition from hope to science, particularly over the last half century. Many of the dynamic present-day scenarios for biodiversity conservation embed insects and other invertebrates firmly within their perspective, although there is still far to go for this to become routine. The foundation traced in this book, endorsed by newer appreciations of both the vital and practical ecological importance and the vast variety of insect life, emphasises that insects are not any trivial discard of human progress, but that their conservation is essential to the wellbeing of humanity within the natural world. Assuring that wellbeing must involve insect conservation, and the challenges to promote this through widespread education and involvement, backed by the best possible scientific and ethical understanding, remain to ensure that this is appreciated, and is a precursor to their effective conservation in the future.

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Index

Note that several of the butterflies discussed in this book are known by more than one scientific name, reflecting different opinions on generic placement or precise status. The index includes these names as used by individual chapter authors, but for full retrieval of information, examination of the following pairs of names is needed: *Mellicta/Melitaea athalia; Phengaris/Maculinea arion; Plebejus samuelis/Lycaeides melissa samuelis*.

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