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Assessing conservation status and trends for the world's butterflies: the Sampled Red List Index approach

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Abstract Red List Indices provide a method for assessing global trends in species' conservation status, and for monitoring progress towards achieving conservation targets (for example, commitments under the Convention on Biological Diversity). Red List Indices are based on categorization of taxa in terms of their threat status using information on, for example, current and projected abundances, distributions, and threats. Global assessments have now been undertaken for a suite of well-known vertebrate taxa. However, highly diverse invertebrate taxa are currently very poorly represented in such assessments, and there is a danger that their threats and their utility as biodiversity indicators will be overlooked. Unlike most invertebrates, butterflies are relatively well-known globally. We describe ongoing efforts to incorporate butterflies into the Red List Index process. Because of high species richness (approximately 15,000 Papilionoidea globally) a comprehensive assessment is not feasible. Instead, we apply a 'Sampled Red List Index' approach which draws on a subset of 1,500 focal taxa. We illustrate the process and the challenges (particularly taxonomic issues and issues of data deficiency) using a variety of case studies. The information provided should be relevant to other researchers seeking to apply the Red List Index approach to invertebrates and other diverse but poorly studied taxa.

Keywords Africa · Extinction · Global · Indicator · Lepidoptera · Red List Index · Monitoring

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Introduction

Approximately 10% of all described species are Lepidoptera: some 180,000 species in total. Of these, about 10% or 18,000 species are butterflies, members of the superfamilies Papilionoidea and Hesperioidea (Robbins and Opler 1997; Ackery et al. 1999). Unlike most Lepidoptera and indeed most non-vertebrates, butterflies are relatively well-studied globally, being perhaps the most charismatic and best-known terrestrial invertebrates. In temperate regions of Europe and North America their status and ecology is thoroughly understood, and individual species have been the focus of intensive—and often successful—single-species conservation efforts (e.g., New 1991; Thomas et al. 2009). Furthermore, butterflies have been widely adopted as ecological indicators for conservation assessments and as indicators of wider trends in the status of biodiversity (e.g., Thomas et al. 2004; Thomas 2005).

However, the great majority of butterfly species are restricted to the tropics: little is known about most of these species and their taxonomy is often uncertain or confused. While we might predict that major anthropogenic drivers such as habitat destruction and climate change are having detrimental effects on their abundance and distribution, no concrete multi-taxa data exist to document this. We do not know what fraction of butterflies globally is threatened with extinction; whether levels of threat vary geographically or taxonomically; what the major threatening processes are, and whether the nature of the threats to butterflies differ from those affecting other taxa.

In this paper, we describe a new and ongoing effort to rectify this situation and to bring butterflies into the mainstream of conservation assessment and planning globally, through targeted application of the Red List assessments and application of the Red List Index (RLI) approach. We describe the rationale of this approach and discuss the practicalities and difficulties of applying it to butterflies.

The Red List and Red List Indices

The International Union for the Conservation of Nature and National Resources (IUCN) provides an internationally-recognized categorization of species in terms of their risk of extinction. Species are allocated to one of nine categories (Table 1) based on factors such as rates of population decline, population sizes, area of geographic distribution, and the degree of population and distribution fragmentation. ‘Threatened’ species (those considered to be of high risk of extinction) are those in the categories Critically Endangered, Endangered and Vulnerable. The specific criteria used to allocate species to categories are summarised in Table 2. For example, under criterion B a species could be assessed as Vulnerable if its geographic range (known as the extent of occurrence) is less than 20,000 km^2, but only if two or more of the following apply: (a) the distribution is severely fragmented or the species occurs in few localities, (b) there is continuing decline in its distribution, or (c) there are extreme fluctuations in distribution. In this example, if the distribution is less than 5,000 km^2 then the species would be assessed as Endangered; less than 100 km^2 then it would be Critically Endangered (IUCN 2001). While the criteria are fully quantitative, precise and detailed information is not essential to apply them (Akçakaya et al. 2000; Mace et al. 2008): assessors are encouraged to use expert knowledge along with the best available information to estimate the relevant values, provided that these limitations are explicitly specified in the accompanying rationale (IUCN 2001). Because Red List categories are so broad, even if estimates of particular parameters used for the assessments (e.g., extent of occurrence) are imprecise, the process will normally still allocate species to a consistent category.

Such assessments are influential in their own right because they draw attention and sometimes funding to threatened taxa that are a high priority for conservation action (Possingham et al. 2002; Rodrigues et al. 2006). Systematic compilations of data on conservation status for multiple taxa have further potential: a snapshot survey of conservation status for a single taxonomic group (e.g., the approximately 9,500 species of birds) can allow conservationists to identify taxa, regions or habitats that are of particular conservation concern (Butchart et al. 2004). Furthermore, if such surveys are repeated regularly then trends through time can be measured. For example, Smith et al. (1993) used the speed at which species climb the ladder of endangerment through time to predict extinction rates.

Similar logic is applied in calculating Red List Indices, which have been adopted by the Convention on Biological Diversity as one of the methods for monitoring progress towards the target to achieve ‘a significant reduction of the current rate of biodiversity loss at the global, regional and national levels’ by 2010 (Secretariat of the Convention on Biological Diversity 2003). The RLI approach was first applied to birds, which have now been comprehensively assessed at a global level four times (Butchart et al. 2004). The RLI works by comparing the number of threatened species in repeated re-assessments. In the revised formulation of Butchart et al. (2007), the RLI value for a given set of assessments falls between 0 (all species are Least Concern) and 1 (all species are Extinct), and allows comparisons between sets of species in terms of their overall level of extinction risk, but also in terms of the rate at which this changes through time. In calculating the index, shifts between particular categories can be given equal weighting so that (for example), if 20 Near Threatened species shift down one category to Least Concern, and 20

Table 1 The IUCN Red List categories

Category	Abbreviation	Description
Extinct	EX	No individuals remaining
Extinct in the Wild	EW	Known only to survive in captivity, or as a naturalized population outside its historic range
Critically Endangered	CR	Extremely high risk of extinction in the wild
Endangered	EN	High risk of extinction in the wild
Vulnerable	VU	High risk of endangerment in the wild
Near threatened	NT	Likely to become threatened in the near future
Least Concern	LC	Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category
Data Deficient	DD	Insufficient data to make an assessment of its risk of extinction
Not Evaluated	NE	Has not yet been evaluated against the criteria

The term “threatened” describes taxa in the categories: Critically Endangered, Endangered, and Vulnerable

Table 2 A simplified overview of thresholds for the IUCN Red List criteria (modified from Butchart et al. 2005)

Criterion	Critically Endangered	Endangered	Vulnerable	Qualifiers and notes
A1: reduction in population size	≥90%	≥70%	≥50%	Over 10 years/3 generations in the past, where causes are reversible, understood and have ceased
A2–4: reduction in population size	≥80%	≥50%	≥30%	Over 10 years/3 generations in past, future or combination
B1: small range (extent of occurrence)	<100 km^2	<5,000 km^2	<20,000 km^2	Plus two of (a) severe fragmentation/few localities (1, ≤5, ≤10), (b) continuing decline, (c) extreme fluctuation
B2: small range (area of occupancy)	<10 km^2	<500 km^2	<2,000 km^2	Plus two of (a) severe fragmentation/few localities (1, ≤5, ≤10), (b) continuing decline, (c) extreme fluctuation
C: small and declining population	<250	<2,500	<10,000	Mature individuals. Continuing decline either (1) over specified rates and time periods or (2) with (a) specified population structure or (b) extreme fluctuation
D1: very small population	<50	<250	<1,000	Mature individuals
D2: very small range	N/A	N/A	<20 km^2 or ≤5 locations	Capable of becoming Critically Endangered or Extinct within a very short time
E: quantitative analysis	≥50% in 10 years/3 generations	≥20% in 20 years/5 generations	≥10% in 100 years	Estimated extinction-risk using quantitative models, e.g., population viability analyses

Critically Endangered species go Extinct, the index value does not change. Alternatively, weights can be applied to emphasise the importance of changes for highly endangered species. Red List Indices can be interpreted as "the proportion of species expected to remain extant in the near future in the absence of any conservation action" (Butchart et al. 2007).

One potential problem with this approach is that many shifts of status will be artifacts, generated because of changing levels of knowledge about individual species, changes to the specific criteria used to categorise species, or taxonomic changes. For example, only 20% of category changes for birds between 2000 and 2004 reflected genuine improvement or deterioration in status (Butchart et al. 2004). The IUCN Red List assessment procedure requires the reason for any category change to be recorded, allowing these 'false' category changes to be excluded from calculation of the index. A further criticism of the SRLI approach is that quite substantial changes to a species' distribution or abundance may not be detected because the categories are so broad; but broad categories seem essential to allow any assessments to take place for less well know taxa such as butterflies. While the 'headline' values for indices should reflect global trends, indices can be usefully 'disaggregated' to provide more focused and comparable information for particular biogeographic realms, habitat types and taxa. For example, while overall Red List Indices for birds have a value around 0.92 and show a gradual decline through time, particularly steep declines in 'disaggregated' Red List Indices have been documented for Indo-Malayan birds, driven by severe deforestation, and for petrels and albatrosses, driven by incidental mortality associated with longline fisheries (Butchart et al. 2007). Such results can clearly be useful in identifying urgent conservation priorities.

Sampled Red List Index (SRLI) approaches

High profile global Red List assessments have now been undertaken for a suite of vertebrate taxa (birds, amphibians and mammals). However, highly diverse invertebrate taxa are currently very poorly represented in such assessments, and there is a danger that their threats and utility as biodiversity indicators will be overlooked. The fact that Red List assessments are likely to be challenging for many invertebrates, including butterflies, should not deter us (Collen et al. 2008). Clearly, there are too many butterfly species in relation to the number of butterfly experts for us to assess the conservation status of each of the earth's species. Instead, we select a random subset of these species for assessment. If the sub-sample is genuinely random, then it should be representative of butterflies more widely in terms of the geographic and taxonomic spread of species as well as their conservation status. Simulations have demonstrated that an initial sample of 1,500 species is sufficient for these purposes, even if a substantial fraction of these species prove to be Data Deficient (Baillie et al. 2008). As for the Red List Index, periodic reassessments of these species should allow us to monitor long-term trends in species' status. The SRLI project for butterflies, supported by the Zoological Society of London, and with funding from the Esmee Fairbairn Foundation in currently underway and should be completed by the end of 2010. Because of particular problems with synonymy and likely high levels of data deficiency, early on the decision was taken to restrict the butterfly Red List Index process to the 'true butterflies' (superfamily Papilionoidea, approximately 15,000 species) and not the skippers (superfamily Hesperioidea, approximately 3,000 species). The project to date has involved data compilation by a network of approximately 60 butterfly experts across the globe. The process should be complete by late 2010 and will be the first global assessment of the status of world's butterflies. The intention is to carry out repeat assessments for the same sample of species approximately every 10 years.

Butterflies on the Red List

Red List assessments of butterflies have been carried out both internationally (taxonomically restricted, e.g., the swallowtail red data book: Collins and Morris 1985) and more locally, e.g., for Europe (van Swaay and Warren 1999; van Swaay et al. 2010) and South Africa (Henning 1989; Henning et al. 2009). At the time of writing (22 March 2010), just 425 Lepidoptera species have global Red List assessments, of which 372 are Papilionoidea (IUCN Red List 2010). This compares very unfavourably with other non-vertebrate taxa, such as plants (Brummitt et al. 2008). Since few of the species included on the SRLI have already been assessed, the SRLI project will increase this total by almost 1,500, in a representative manner. The existing coverage of butterfly assessments is very patchy and idiosyncratic, and a large fraction of existing butterfly assessments appear either to apply the criteria incorrectly, or are out of date because they are based on earlier definitions of categories and criteria which were more subjective and less quantitative than those currently applied. The taxonomic and geographic coverage of existing Red List butterflies is also very uneven, and biased towards 'popular' taxa and regions. Furthermore, of those species currently listed as threatened, a large fraction appears to have been accorded a threatened status that exaggerates the risk of extinction. Understandably, many international butterfly experts approached to assist with the SRLI project were initially very skeptical of the idea of applying the Red List Criteria to butterflies. Clearly, a general understanding of the status of butterflies globally is unlikely to emerge from an ad hoc approach to Red List assessment, and the more systematic approach being applied through the SRLI should help in this regard. An additional, beneficial side-effect of the SRLI project is that it will greatly broaden the geographic and taxonomic spread of butterflies represented on the Red List, as well as greatly increasing the total number of species included. The SRLI approach has already been applied successfully to other invertebrate taxa, including Odonata (Clausnitzer et al. 2009) and freshwater crabs (Cumberlidge et al. 2009).

Practicalities of the butterfly SRLI

Generating a species list for the assessments

Surprisingly, considering that butterflies are generally thought to be among the best-studied insects in terms of their taxonomy and ecology, there is still no global checklist of butterfly species names. This provides a major challenge for the sampled approach to Red Listing, since the random subset of species for assessment purposes must be drawn from a global list. Considerable effort was made at the start of the Red List Index project to make our species selection as unbiased as possible. Initially, our list was based on LepIndex (Beccaloni et al. 2003), a catalogue maintained by the Natural History Museum, London. LepIndex is the only source which contains (in theory) all the global Lepidoptera names, although species described since about 1980 are not included. The problem with LepIndex is that most of these names are "species group names" that do not necessarily correspond to species: 75% of the names on the list represent invalid junior homonyms or subspecies names (G. Beccaloni, personal communication).

We used LepIndex to generate information on the fraction of species to be drawn from each biogeographic realm; these values were consistent with information in other sources (Table 3). In the case of Afrotropical, Australasian and Neotropical faunas we were then able to use new and up-to-date data collated under the Butterfly

Table 3 Representation of butterflies on the Red List Index by Biogeographic Realm

Biogeographic realm	Estimated % of global fauna	Species to be assessed
Neotropical	42	630
Afrotropical	21	315
Oriental	14	210
Australasian	8	120
Palaearctic	11	165
Nearctic	4	60
Total	100	1,500

Estimates of species numbers exclude Hesperioidea and are based on a consensus assessment using Heppner (1991), Robbins and Opler (1997), and Larsen (2005a) in combination with the standardised random draw of taxon names from LepIndex

Taxome Project (Mallet 2007) to build species lists. Thus, for these regions the strategy chosen has been to ignore the names generated using the random draw from LepIndex and instead select directly from the up-to-date list appropriate numbers of taxa to reflect the proportion of the global butterfly fauna represented in each biogeographical realm (Table 3). If the random names picked in LepIndex came from biogeographic realms not currently covered by the Butterfly Taxome Project (in particular the Oriental and Palaearctic realms), our strategy was to search using printed or online information to pin down an appropriate classification. If we were unable to determine the name's status (and species), then we dropped that species from the list and picked the next species off a 'reserve list' for the same biogeographic realm. Although different approaches were necessary for different biogeographic realms, we emphasise that the species selection is genuinely random and is not for example stratified taxonomically. The aim is to represent butterflies as a taxon, and therefore the randomly-selected species should be representative of all butterflies in terms of the fraction of species included from each biogeographic realm, habitat and family.

Applying the Red List categories and criteria to butterflies

The first hurdle to overcome in assessing the Red List status of butterflies is that the original IUCN Red List categories and criteria were designed essentially for vertebrates (IUCN 1966; Mace et al. 2008). More recently, extensive efforts have been made to increase the applicability of the criteria to other taxa (IUCN 2001), but there are still limitations in their applicability for groups like butterflies. This is as much to do with data availability as it is to do with the specification of the criteria.

For butterflies, criterion B is the primary criterion used for assessments, as for most other invertebrate and plant groups. Criterion B categorizes species according to the extent and rate of decline of their geographic range, measured as extent of occurrence (EOO) and/or area of occupancy (AOO) (IUCN 2001). The EOO is the smallest area within a boundary covering the total extent of observed, projected or inferred species records (Gaston 1991). The AOO includes solely the area within the EOO that the species actually occupies. For instance, an EOO will include areas of unsuitable habitat or uncolonized areas, but the AOO records only the occupied area within the EOO (Gaston 1991). For most butterfly species, the EOO is straightforward to calculate as a convex polygon based on locality records. However, measurement of AOO is more complicated as it requires comprehensive species or habitat records collected at an appropriate spatial scale (IUCN Standards and Petitions Subcommittee 2010).

Criterion D2 is also regularly used for butterfly assessment; it is applied if a species faces current or future threats and has a very restricted AOO, or is found in fewer than five locations (IUCN 2001). Only on rare occasions are criteria other than B and D2 applied to butterfly assessments. The population data required to apply criterion A are rarely available for butterfly species, although they have been used widely in recent Red List Assessments for European species, where transect-based monitoring data exist for some countries (van Swaay et al. 2010). In a few cases, criteria A2–4 can be applied based on inferred population declines resulting from habitat loss or degradation.

Data deficiency

Butterflies are a well known taxon when compared to other invertebrates but are extremely poorly known when compared to many vertebrates. Our knowledge of the world's butterflies is highly variable, both taxonomically and geographically. In terms of the challenges posed by different butterfly families, the Riodinidae and Lycaenidae are most problematic. These families have much in common, often exhibiting highly specialised ecological relationships such as myrmecophily (Cottrell 1984), and having localised distributions (New 1993). While the Riodinidae are mostly Neotropical, the Lycaenidae are globally distributed; this is the most speciose butterfly family with approximately 6,000 species. Many are known from a handful of records, and some from the type specimen alone. Geographically, the problems are compounded by the fact that the highest species richness of butterflies is in tropical forests, some of the most data poor and most difficult to study areas. For example, around 20% of the world's butterfly species occur in Colombia, a country that makes up <1% of the earth's land area (Le Crom et al. 2002; Le Crom et al. 2004).

Because of these problems, a large proportion of butterflies selected for the SRLI have been categorized as Data Deficient (DD). A listing of DD indicates that too little is known about the species' distribution, status or threats to make an assessment of its extinction risk (IUCN 2001). Initial results from the Afrotropical species included in the SRLI suggest that around 15% are classed as DD and this seems likely to be representative of the global trend. To put this in perspective, on the current Red Lists only 1% of bird species, 15% of mammals, 25% of amphibians and 17% of reef-building corals are listed as DD (IUCN 2010). Preliminary indications from parallel SRLI exercises on Odonata (dragonflies) and Scarabaeidae (dung beetles) indicate that 35–40% of species in those taxa are likely to be categorised as DD (Clausnitzer et al. 2009; S. Spector, personal communication 2010). This suggests a lower fraction of DD butterflies compared to other invertebrates.

Alternatively, it may be that butterfly assessors are more willing to assess species based on low levels of data and greater uncertainty. Under IUCN guidelines, two key concepts in this context are dispute tolerance and risk tolerance (IUCN Standards and Petitions Subcommittee 2010). Dispute tolerance is the extent to which an assessor excludes extreme values from an assessment. Low dispute tolerance, including extreme values, increases the uncertainty of the assessment. Risk tolerance is the extent to which an assessor adopts an evidentiary (high risk tolerance) or precautionary (low risk tolerance) attitude towards risk (IUCN Standards and Petitions Subcommittee 2010). Precautionary assessors will assess a species as threatened unless it is highly unlikely that the species is not threatened, whilst an evidentiary assessor only classes a species as threatened if strong evidence supports that classification. The IUCN supports the general view that a moderate dispute tolerance and a low risk tolerance should be adopted (IUCN Standards and Petitions Subcommittee 2010). This should minimize the use of the DD category whilst maintaining accuracy in assessments, although it does introduce greater subjectivity.

In assessing butterflies for the SRLI we have tried to adhere closely to the IUCN's view on risk and dispute tolerance. However, the limited data available have led to greater projection and inference than is likely to be typical for better-known taxa. The majority of our assessments are thus characterized by low dispute tolerance and an inevitable low risk tolerance, as strong evidence is not available for many species and we try to use whatever limited, but reliable, data are available. Assessors working on groups such as mammals and birds are likely to adopt more of an evidentiary attitude whilst still maintaining a low risk tolerance, simply through having access to a greater volume of data.

Taxonomic uncertainty

Although butterflies are relatively well characterized taxonomically compared to other invertebrates (Wahlberg et al. 2005), we have still encountered widespread problems with synonymy, unresolved taxa and incorrect classification. It is not easy to assess the conservation status of a species when you don't know what that species is. Some of these problems are illustrated by the genus *Melinaea* (Nymphalidae: Ithomiini) in the Neotropics. Ithomiines include numerous Müllerian mimics which make their identification difficult. Furthermore, Müllerian mimicry rings involve multiple genera and even multiple families (Joron and Mallet 1998), so *Melinaea* spp. can also be confused with more distantly related species. Intraspecific polymorphism within *Melinaea* spp. and between subspecies further complicates matters, and molecular studies have had varying success in differentiating morphological species within the genus (Whinnett et al. 2005; Elias et al. 2007; Dasmahapatra et al. 2009). Mitochondrial DNA barcoding failed to identify any distinct groups, whilst AFLP markers had some success in dividing the genus into more distinct morphological groups (Dasmahapatra et al. 2009). Until these problems are resolved, most *Melinaea* spp. are likely to be considered Data Deficient.

Case studies

Even if we can overcome taxonomic problems, challenges in applying the Red List criteria remain. We will illustrate some of these problems using two Afrotropical case studies, from a part of the world where the extent of deforestation has been spectacular, but few if any butterfly extinctions have been documented (Larsen 2008).

Liptena ilaro

This lycaenid was described in 1974 from the Ilaro Forest in Nigeria but has not been collected since the original type series in 1967 (Larsen 2005b). Ilaro is close to the Nigerian capital Lagos, in the most densely populated area of Nigeria. The Ilaro Forest was totally cleared in the 1980s by illegal logging. No forest remains in the Ilaro area, and little more than 100 km^2 of severely fragmented forest is left in the nearby Ibadan area (Manu et al. 2005). The extent of occurrence (EOO) of this butterfly appears to be less than 5,000 km^2 and the area of occupancy (AOO) less than 100 km^2. With ongoing decline in the butterfly's EOO, AOO and habitat, and severe fragmentation of its distribution, the species seems likely to qualify as Endangered under the B criteria.

However, there are arguments for both a lower and higher threat classification. The species has not been recorded for over 40 years, its rare forest habitat has now been largely destroyed and no detailed data are available on forest cover, AOO or EOO. Therefore, it is possible that the species is Critically Endangered or perhaps even Extinct in the Wild. On the other hand, butterflies from the tribe Liptenini are able to persist in small forest fragments, this species is only readily identified by experts and there has been little recent collecting in the area of Nigeria where this butterfly occurs (T. B. Larsen, personal communication 2008). Thus, there is a slight possibility that *L. ilaro* could be Vulnerable or Near Threatened.

In this situation, we return to the concept of risk tolerance. A purely evidentiary (high risk tolerance) approach would classify the species as Vulnerable or even Data Deficient, whilst a precautionary approach would categorise the species as Critically Endangered. Extinct seems less appropriate for *L. ilaro*. The IUCN encourages an evidentiary approach when classifying extinctions, in order to promote ongoing conservation measures, and requires exhaustive surveys in all possible habitat (IUCN Standards and Petitions Subcommittee 2010). The IUCN suggests that a tag (not category) of possibly extinct is used in certain situations, for instance when severe threatening processes have occurred (IUCN Standards and Petitions Subcommittee 2010). In this case, a classification of Critically Endangered (possibly extinct) may be appropriate for *L. ilaro*.

Pseudaletis arrhon

This Afrotropical lycaenid has been given a preliminary classification of Data Deficient and is typical of the numerous DD species encountered whilst carrying out the SRLI. It is only known from its male type specimen collected from Bitje in southeastern Cameroon around 100 years ago (Libert 2007). Theclinae of this genus are normally extremely localised and elusive as a result of obligate associations with *Crematogaster* sp. ant nests found in particular trees (New 1993). Recent targeted collecting by the African Butterfly Research Institute around *Crematogaster* nests has resulted in a huge increase in Theclinae specimens, but no further specimens of this species. This suggests that the species could be threatened; however, there are still large areas of forest remaining in southeastern Cameroon (FAO 2005). Although we aim to take a precautionary approach and the area has been reasonably well researched by lepidopterists, until the area has been more thoroughly surveyed it would be inappropriate to consider any classification other than DD for a species which is known from just a single specimen, and which is likely to be naturally local in its distribution and elusive in terms of its behaviour.

Conclusions

We believe that the Red List Index approach has considerable potential for informing conservation policy and practice, and that butterflies, as ‘flagship’ terrestrial invertebrates (New 1991), should be part of this process. Other approaches to monitoring trends (e.g., the Living Planet Index) rely on long-term population data, which are very rarely available for butterflies and other invertebrates (Butchart et al. 2010). Here we have discussed the role of butterflies in global conservation assessments, but equivalent processes can and should be applied at regional scales. National level Red List assessments are now increasingly including butterflies, for example the recent Brazilian and Venezuelan red data books (Machado et al. 2005; Rodríguez and Rojas-Suárez 2008). While we have focused on the Red List Index approach, the wider benefits of more systematic approaches to Red Listing of butterflies (and other invertebrate taxa) are worth emphasizing. Only with standardization can we hope to know what fraction of butterflies globally is threatened with extinction, whether this is representative of other terrestrial taxa, and where the most urgent areas for conservation action are located.

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