Chapter 6
Towards EcoEvoEthics

Patrick Blandin

Abstract Ecology long considered the natural world as an "equilibrium world". This view culminated in the 1950s with the ecosystem paradigm, which was strengthened by the idea that the reciprocal selection of interacting species should produce ecological stability. At the end of the 1940s, Aldo Leopold's Land Ethic valued the stability of natural communities, and the balance of nature became a key issue for conservationists. Nowadays, there is a shift towards a co-change paradigm: interacting biological and non-biological entities are co-changing through a transactional web that forms the biosphere. Consequently, as ecology meets evolution, the conservation target must shift from the stability of ecological systems to their adaptability. Simultaneously, there is a need for an eco-evolutionary ethics which assumes that we and our co-evolving aliens are living in a changing world. Difficult issues should therefore be addressed, such as the uniqueness and intrinsic value of living entities versus the substitutability of functionally redundant species, and the evolutionary value of diversity. Finally, beyond the biocentrism versus anthropocentrism debate, this EcoEvoEthics should affirm that a thing is right when it tends to enhance the biosphere's capacity to evolve.

In 1949, Aldo Leopold justified his proposal for a new ethic – the Land Ethic – explaining that, in humanity's history, there has been an extension of ethics: ethics dealt first with the relation between individuals, and later with the relation between the individual and society. Leopold considered this extension as an evolutionary process, ethics being possibly a kind of community instinct providing guidance for meeting ecological situations. Stating that there was as yet no ethics dealing with people's relation to ecological communities, Leopold wrote that the extension

P. Blandin (✉)
Department Men-Natures-Societies, Ecoanthropology and Ethnobiology,
Muséum National d'Histoire Naturelle, 75005, Paris, France
e-mail: blandin@mnhn.fr

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of ethics to this third element was an evolutionary possibility and an ecological necessity. This idea should be considered in the light of evolutionary ethics, which was initiated by Thomas Henry Huxley and developed as an important field during the very last decades, though not without debate (Wilson 1975; Ruse 1986, 2009; Ayala 2006; Boniolo and De Anna 2006). The fundamental idea is that the emergence of the human capacity to elaborate Ethics could be an evolutionary process, shaped by natural selection: ethical behaviour should enhance the probability of group survival. Leopold's "environmental ethics," which deals with principles of nature conservation, should appear as a significant step in humanity's search for survival within the fragile community of life on earth.

Fifty years after Leopold's Land Ethic, the Chilean philosopher Ricardo Rozzi (1999) proposed checking on the existence of reciprocal influences between ecosystems theory and environmental ethics as a possible illustration of his general statement: "Ethics and science establish a dialectic interrelationship that evolves historically through mutual and successive modifications." In this chapter, I shall explore the way ethics for nature conservation and ecology entered into such a dialectical process, and I shall argue that, as ecology undergoes a dramatic change of paradigm, from "equilibrium" to "change," environmental ethics must acquire a genuine evolutionary dimension.

6.1 An Equilibrium World and the Ecosystem Paradigm

Ecology, as a scientific field, has its roots in the nineteenth century (Golley 1993; Acot 1998). The structuring of natural communities gradually became a central topic with the development of descriptive studies for terrestrial and aquatic communities of species composition, of phenology, and of relations with environmental factors. Limnologists played an eminent role in this process. In 1887, the American Stephen Alfred Forbes, describing the lake as a "microcosm," focused on the concept of a "community of interest," defined as a community of interacting species shaped by natural selection, the "beneficent power" of which compelled "such adjustments of the rate of destruction and of multiplication of the various species as shall best promote this common interest" (Forbes 1887, 87). Clearly, Forbes considered that the selection process produced an equilibrium that was steadily maintained (barring dramatic changes in local conditions), which for all the parties involved achieved the greatest good permitted by the circumstances.

Plant ecologists have also become very active since the end of the nineteenth century. In 1910, the Frenchman Charles Flahaut and Carl Schröter from Switzerland coined the concept of a plant association: a plant community with a precise species composition, adapted to precise ecological conditions. The American Frederic Clements elaborated the theory of the development of plant communities towards an equilibrium state, the "climax" (Clements 1916). Ideas converged on both sides of the Atlantic: phytogeographers recognized that plant communities adapt to their environment and, once adapted, remain at equilibrium unless the ecological context changes. These ideas had obvious similarities with Forbes's conception. Thus, pioneer ecologists were giving primacy to the concept of natural equilibrium.

The English botanist Arthur George Tansley (1935) elaborated the ecosystem concept as a rebuttal to a burst of papers published by John Phillips, a South African botanist who applied Jan Christian Smuts's concept of holism to ecological communities and promoted Clements's metaphoric view of the plant community as a super-organism (see Bergandi 1999). Tansley claimed that the smallest unit of nature – the "ecosystem" – includes not only plants, but all the biotic components (plants, animals, microorganisms) and their physical environment (the abiotic context). Tansley considered that, within an ecosystem, biotic and abiotic factors are in a relatively stable dynamic equilibrium.

The limnologist Raymond Laurel Lindeman (1942), who worked with George Evelyn Hutchinson at Yale University, developed a brilliant synthesis between quantitative research on food webs, Clements's succession and Tansley's ecosystem. He introduced the concept of a "trophic equilibrium," a dynamic process of the use and regeneration of nutriments, supported by a continuous energy flow. In the spirit of Lindeman's paper, in 1953 the American ecologist Eugene Pleasants Odum, assisted by his brother Howard Thomas Odum, published *Fundamentals of Ecology*, the keystone book of modern ecology. Lindeman's and Odum's approaches were both systemic, with Odum's book giving the ecosystem concept a paradigmatic role (Bergandi 1995).

In the USA, ecology rapidly met system analysis and cybernetics, thanks to the availability of the first digital computers (Golley 1991). The use of ecosystems analysis and of cybernetic models, or "eco-cybernetics" (Bergandi 2000), has been at the heart of ecological research for decades. The ecosystem was considered a cybernetic entity, structured by interactions within species and the environment, and maintained in a dynamic equilibrium by feed-back processes. Moreover, with the development of the concept of a dynamic equilibrium sustained by a continuous energy flow, the thermodynamics of open systems consolidated ecosystem theory.

Darwin's theory was used early on to justify ecosystem stability. Forbes (1887) was perhaps the first to put forward the idea that species communities are shaped by natural selection, with their stability resulting from the tight adjustment of the various species dynamics. A century later, John A. Wiens (1984, 440) wrote: "Ecology has a long history of presuming that natural systems are orderly and equilibrial (the 'balance of nature' notion; . . .), and the infusion of evolutionary thinking into ecology strengthened this view, providing a mechanism (natural selection) that may lead to the development of optimally structured communities." In the meantime, Tansley (1935) supposed the existence of a kind of competition between ecosystems, with those reaching a more stable equilibrium having a longer survival time. In this way, evolutionary theory favoured a non-evolutionist ecological thought, stability being considered as the normal state of ecosystems, when undisturbed by humans. A very emblematic reflection of this conceptual framework can be found in *Evolutionary Ecology* (Shorroks 1984), a volume that resulted from the 23rd Symposium of the British Ecological Society.

The final chapter is entitled "Genetic diversity and ecological stability," in which the author concludes "that the plasticity produced by genetic diversity as a result of ecological interactions is an important factor in maintenance of persistence in ecosystems" (Mani 1984, 394).

For decades, ecologists worked mainly on situations existing at one particular moment of time, in one particular area. They could work with peace of mind: the "equilibrium competitive community paradigm" (Wiens 1984, 456), reinforcing the ecosystem paradigm, provided a perfect umbrella. As stated by Robert E. Ricklefs (1987, 167), "present-day ecological investigations are largely founded on the premise that local diversity – the number of species living in a small, ecologically homogeneous area – is the deterministic outcome of local processes within the biological community." This hypothesis gave hope that there are general laws connecting ecological context, competition, natural selection, and the species diversity of communities.

Paradoxically, while the synthetic theory of evolution was spreading among biologists, providing a general framework for biology, it supported the development of an ecological theory favouring a static view of nature: contemporary ecosystems were supposed to have reached a stable state, shaped in the past and now maintained by natural selection. In this intellectual context, man was necessarily viewed as an external, perturbing factor in otherwise "perfect" nature.

6.2 Protection of Nature: The Path to Ecology

During the eighteenth century, emblematic decisions were taken for the protection of forests in some tropical islands in French and British colonies. These decisions were inspired by "proto-ecological" conceptions that dealt with relationships between forests, climate, and water availability, and they provided models for conservation actions, for example in India (Grove 1992). But areas were also protected in the nineteenth century for purely aesthetic reasons. In France, as early as 1853, the Barbizon Painters, who worked in the Fontainebleau Forest, succeeded in obtaining the creation of a small (624 ha) "artistic reserve," where nature was protected for its landscape beauty. In the United States, the first national park, Yellowstone, was created in 1872 in an effort to protect vast areas of wilderness and satisfy public aesthetic and moral yearnings and a thirst for outdoor recreation. At the end of the century, the preservationist John Muir, influenced by Ralph Waldo Emerson's and Henry David Thoreau's philosophy of nature, was an active promoter of "wilderness" preservation as the purest representation of divine creation. This same period saw rising awareness of the extinction of wild species, with the most emblematic action being William Temple Hornaday's fight for the survival of the American bison (Hornaday 1889). At the international level, agreements were signed in 1883 in Paris for the protection of sea mammals in the Bering Sea and in 1902 for the preservation of "useful birds."

US President Theodore Roosevelt was influenced by John Muir, but much more by the forester Gifford Pinchot, who developed a utilitarian conception of nature conservation. Roosevelt planned an international conference on conservation to be held in The Hague in 1909, but his successor killed the project (Holdgate 1999). Europe also saw the rise of movements for the protection of nature. In 1905, the "Congrès International pour l'Art Public," held at Liège, adopted a resolution for the creation of natural parks, presented by a French agronomist and lawyer, Raoul de Clermont. An international movement was launched in 1910 by the Swiss naturalist Paul Sarasin, and an international office for the protection of nature was created in 1913, but this trend was interrupted by World War I. The movement regained momentum in 1923 with the First International Congress for the Protection of Nature, held at the Muséum National d'Histoire Naturelle, in Paris, with Raoul de Clermont as its general secretary. The congress considered many aspects of nature conservation, including fauna, flora, fossils and minerals deposits, natural monuments and landscapes.

Academic ecology was notable for its absence at the Paris congress. There was no consideration of communities, in Forbes's or Clements's sense. Zoologists and botanists focused on endangered species and habitats (sometimes using the word "station," meaning the local site of a plant association), but without a genuinely ecological approach. It was only 25 years later, in 1948, when the International Union for the Protection of Nature (IUPN)[1] was created by an international conference held in Fontainebleau, that the Union founders advocated the development of research in ecology (UIPN 1948). For the first time in an official context, conservationists recognized that ecology should be a key science for the protection of nature. The IUPN held its first Technical Conference at Lake Success (USA) in 1949 (UIPN 1950). A preparatory document was published (UIPN 1949), including parts of a previous paper by Jean-Paul Harroy, the IUPN General Secretary, who pointed out a radical change taking place in the protection of nature. Harroy argued that protection should no longer limit itself to the sentimental point of view that had persisted for so long in protectionist thinking. Especially as mankind became increasingly anxious due to the sombre predictions of economists, protection needed to take on board a utilitarian perspective. This change – with the idea that nature conservation and the economy are linked – pointed to the crucial need for a scientific study of natural communities, and ecology appeared to be the appropriate science.

As a matter of fact, an important portion of the Lake Success Conference was devoted to ecology. This was introduced by a paper entitled "Protection de la nature et écologie," presented by a French biologist, Georges Petit (1950). Petit, who had participated in the Paris congress in 1923, emphasized the fact that relationships between the protection of nature and ecology had been widely neglected, as the former had long been motivated only by aesthetic and moral concerns. Petit said that, by the way, protection was considered for a long time as no more than an art added to the study of nature.

Although the term "ecosystem" had been proposed more than 10 years earlier (Tansley 1935), it was never referred to at Lake Success. The "association" or "natural community" was the central concept. Petit (1950), for example, focused his paper on "vegetational complexes." He explained that, in tropical countries, the vegetation, not modified by man, was a complex that resulted from an evolutionary process, with its physiognomy and composition tightly linked to the present local conditions: a perfect image, he said, of what botanists had named the climax. In this kind of complex, Petit added, phytosociologists see the expression of a stable, equilibrated plant association: Flahaut's and Clements's influences were obvious. In fact, the concept of a "natural equilibrium," or a "balance of nature," was at the heart of the conference discussions, with the disruptive factor in this natural equilibrium ranging from the introduction of an exotic species to the extermination of big game herds and the unwise use of powerful modern insecticides, as explained by the IUPN General Secretary in his introduction to the proceedings (Harroy 1950).

It is important to grasp the conceptual situation at this moment when the conservationist movement met ecology. Harroy's viewpoint (1949) illustrates conservationists' expectations. He considered that, to efficiently protect useful natural associations, man must have studied them carefully beforehand. But to study these associations in the best conditions – Harroy wrote: "in the state of a pure body" – man must have protected them. In appropriate and sufficiently vast areas, shielded from human influences that mask and distort fundamental processes, researchers should attempt to observe these processes and to order them into laws. This statement is symptomatic of what we can call the "virgin nature ideology," which considers man as an external factor, whose interference makes it impossible to understand the real properties of nature.

6.3 Ecocentrism, the Ethical Counterpart of the Ecosystem Paradigm

The Paris Congress report is important for understanding the ideological background and scientific context of nature protection at the beginning of the twentieth century (Clermont et al. 1925). In his closing address, Professor Louis Mangin, the Director of the Muséum National d'Histoire Naturelle, expressed the idea that conservation was necessary not only for aesthetic or moral reasons, but also for practical ones: natural richness was being destroyed, when prudent use would allow its perpetuity. This view was rather similar to Pinchot's conception of natural resources conservation. Nevertheless, during the congress, the dominant values underlining concern for protection were the rarity of species, the beauty or scientific interest of animals and plants, and the artistic, historical or legendary interest of natural sites and landscapes. Protection ethics, at that time, reflected a mixture of biocentrism – awareness about endangered species that science would never be able to recreate, as Louis Mangin put it – and cultural anthropocentrism.

Introducing his Land Ethic, Leopold (1949, 214) wrote: "An ethic to supplement and guide the economic relation to land presupposes the existence of some mental image of land as a biotic mechanism. We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in." Leopold described a kind of virtuous circle, linking scientific knowledge and ethics, which could also be interpreted according to Rozzi's view of the interrelations between science and ethics (Rozzi 1999).

Leopold was not comfortable with the "balance of nature" image, despite its common use, probably because it provided no scientific view of reality. Thus, he proposed as a much truer image a concept employed in ecology, the "biotic pyramid," to evoke the complex web of food chains within a biotic community. He observed that the stability of this system proves it is a highly organized structure that functions through the co-operation and competition of its diverse parts. Moreover, Leopold considered that such stable, organized structures result from a long evolutionary succession of adjustments between parts: his vision was close to Forbes's conception of the community of interest, and to the views of Tansley, who considered that the degree of perfection of the ecosystem equilibrium is revealed by its level of stability (Tansley 1935).

Leopold did not use the ecosystem concept, which at that time remained uncommon, but it is obvious that his conception of "land" was fully congruent with this. The Land Ethic values both the integrity and the stability of the biotic community, and Leopold held that conservation is the effort to preserve the land's capacity for self-renewal. Clearly, in Leopold's mind, the preservation of the integrity of the land/ecosystem, that is the conservation of all its components, was the condition for maintaining its stability and capacity for self-renewal. Leopold's ethic was thus in tune with contemporary ecological knowledge, focusing on biotic communities and later on ecosystems: it has been characterized as "ecocentric," as it values interdependences between the diverse parts, including humans, of ecological systems (cf. Callicott 1989).

6.4 Ecology Meets Evolution: The Co-change Paradigm

As early as 1973, Amyan Macfadyen, in his presidential address to the British Ecological Society, noted that some ecologists argue that ecology, like human history, is concerned with unique events which are not supposed to be open to the "scientific method" (Macfadyen 1975). Recently, in the same spirit, Peter Taylor and Yrjö Haila (2001) have pointed out the on-going shift from an ecological theory that is willing to elaborate general laws towards theories that take into account historical contingency, non-equilibrium dynamics, and the uniqueness of many situations.

This conceptual shift was pinpointed in 1987 by Robert E. Ricklefs: ecologists, he said, were realizing that local diversity bears the imprint both of global processes such as dispersal and species production and of unique historical circumstances. Ricklefs emphasized the necessity to consider the balance both between local and regional processes and between short-term events and long-term processes in order to understand species diversity on a local scale. Considering that, through interactions between species, selection favours increased competitive ability and predator efficiency, he concluded that evolution, while fostering greater accommodation among coexisting species, ultimately tends to reduce species richness. Ricklefs affirmed that this reduction is balanced by the immigration of individuals from other areas, the variety of which depends both on regional processes such as the generation and dispersal of new species and on historical accidents and circumstances that are related to past climate history and the geographical position of dispersal barriers and corridors.

Moreover, Ricklefs underlined that the historical dimension of any ecological system results in a diversity of local situations. In doing so, he laid the foundations for the concept of the historical trajectory of an ecosystem: in its present state, any ecosystem is the product of processes that unfold over time, marking out a unique history. Interestingly, the term "historical ecology" was not coined by ecologists, but by anthropologists working on interactions between human populations and their ecosystems and landscapes. Key roles were played by Carol L. Crumley, with her studies on Burgundy (Crumley and Marquardt 1987) and her direction in 1994 of *Historical Ecology: Cultural Knowledge and Changing Landscape*, and by William Balée (1992, 1995), a specialist of Amazonia.

At the same time, landscape ecology also favoured an important conceptual shift, by introducing a new way of looking at the spatial organization and dynamics of ecosystems (see for example Forman and Godron 1986). Disturbance, which was previously considered as perturbing normal equilibria, now appeared as the driving process behind mosaic landscapes. This idea took shape progressively, with the book *The Ecology of Natural Disturbance and Patch Dynamics* (Pickett and White 1985) marking a milestone. Later, Wu and Loucks (1995) went so far as to describe the emergence of this field as a paradigm shift, from the "balance of nature" to "patch dynamics."

Nowadays, it is obvious that each ecosystem and each landscape is a step along a unique trajectory. As local, regional and global processes are continuously interacting, evolution can no longer be considered in the limited sense of species originations and extinctions: it is a global process of coevolutionary interactions and ecological changes.

The earth sciences have highlighted the permanent changingness of our planet and of life on it, over a history of increasingly intertwined relationships between biotic and abiotic processes. The evolution of the biosphere must therefore be considered as a web of interdependent trajectories. As part of broadening the perspective, the Israeli ecologist Zev Naveh (2000) suggested that the "Total Human Ecosystem" should be regarded as the highest coevolutionary ecological entity on earth: he considered evolution as a dynamic process of self-organization and coevolution in nature and human societies. I suggest calling the evolving ecological web the "transactional web" in the spirit of Dewey's transaction concept (Dewey and Bentley 1949; see also Bergandi and Blandin 1998), which was transposed to ecological systems by Hills (1974).[2] Transactions, i.e. simultaneous, reciprocally determined changes between interacting entities, occur between physical environments and living systems, as well as between coevolving species, on every scale through the transactional web. Clearly, a "co-change paradigm" is taking the place of the "equilibrium paradigm" (regarding the transactional framework see 1.2 by Bergandi in this volume).

6.5 An Eco-evolutionary Ethics Is Needed

Can the conservation of nature be a fight against change? Acknowledging the fact that nature is definitively not a subtle, integrated equilibrium, but is intrinsically chaotic, and thus unpredictable, the French philosopher Catherine Larrère (1997) asked whether the integrity and stability of the biotic community, emphasized by Aldo Leopold as key values, had any sense. If everything is changing, how can we know what is right, what is wrong? Ecocentrism was the ethics produced in interaction with the ecologists' conception of an "equilibrium world": it is ultimately insufficient to provide values and principles for action in an evolving world. The paradigm shift in ecology now calls for a new step in the development of environmental ethics (Blandin 2004).

In 1957, the first UNESCO director general, Julian Sorell Huxley, who played a fundamental role in the creation of the International Union for the Protection of Nature in 1948, published a book in which he stated that man has a responsibility for the whole future of evolution. The same idea was promoted later by Otto Frankel (1974), and then again by Otto Frankel and Michael Soulé (1981) in their seminal book, *Conservation and Evolution*. Considering "the more stringent requirements for long-term conservation, involving the maintenance of the evolutionary potential, the capacity to evolve in response to environmental change," Frankel and Soulé introduced the fundamental idea of "evolutionary potential." In this scientific context, the aim of nature conservation should be to preserve the biosphere's evolutionary potential, in order to maintain the sustainability of ecological processes, despite changes in the composition and organization of ecological systems. The biosphere's permanent adaptability becomes the target.

Hutchinson (1964), commenting on Forbes's microcosm, underlined the fact that Darwin and Forbes were conscious that the struggle for life produces harmony. Hutchinson considered it was possible to go further, because at any scale in the universe harmony implies diversity. As we lack a less diversified universe for comparison, Hutchinson said, we cannot know whether diversity is definitely a significant property of our Universe, but we feel that it could be important and we need to appreciate it properly. Ecologists had developed ideas on this point. Relationships between the stability of ecosystems and the diversity of their species have been explored at least from the end of the 1950s, and many ecologists supported the idea that the more diverse an ecosystem is, the more stable it is. In 1975, Daniel Goodman reviewed the empirical and theoretical attempts to check this idea of a direct relationship between the species diversity of a community and its stability. His conclusion was negative: at that time, the expectations of the diversity-stability hypothesis were not borne out by experiment, observation, or models. Nevertheless, Robert M. May (1984, 6–7) noted that, "The idea that complex ecosystems, with many species and a rich web of interactions, should be more stable than simple ones is an intuitively appealing one; it may seem that a community is better able to cope with disturbance if there are many alternative pathways along which energy and nutrients may flow." As a matter of fact, 20 years after Goodman's criticisms, the hypothesis was still being taken into consideration: Silver and her colleagues (1996), for example, argued that functional diversity, and not just species richness, is important in maintaining the integrity of nutrient and energy fluxes. However, these authors underlined that high species richness may increase ecosystem resiliency following disturbance, thanks to a high number of alternative pathways for the flow of resources.

Recently, an international group of ecologists reviewed the current state of knowledge, and concluded that experiments and models support the idea that ecosystem performance depends on species diversity (Hooper et al. 2005). Nevertheless, they focused more on relationships between diversity and "ecosystem services" than on the capacities of ecosystems to adapt and evolve. They forgot Hutchinson's path-breaking idea, expressed as follows: "Just as adaptive evolution by natural selection is less easy in a small population of a species than in a larger one, because the total pool of genetic variability is inevitably less, so it is probable that a group containing many diversified species will be able to seize new evolutionary opportunities more easily than an undiversified group" (Hutchinson 1959, 156). In an evolutionary perspective, the sustainability of an ecosystem implies not only functional continuity (which could result from alternation between redundant species), but also the persistence of its capacity to evolve, which depends on the ecosystem's levels of genetic and species diversities. I explored such ideas, proposing, schematically, two different adaptive strategies, called "cenotic" strategies (Blandin et al. 1976; Blandin 1980). On the one hand, the adaptability of ecosystems with a low species diversity would depend on the genetic diversity – and consequently on the adaptability – of a few species carrying out keystone functions. On the other hand, the adaptability of ecosystems with a high species diversity would depend on the existence of functionally redundant species with different ecological aptitudes, with some species substituting for others under new environmental conditions. These two ecosystem strategies were considered opposite poles of a gradual range of situations: the "evolutionary potential" of an ecosystem depends on a particular combination of species diversity and genetic diversity within each species. This combination results from the past trajectory of the ecosystem.

Nowadays, ecologists also recognize that, at the landscape scale, the diversity and spatial arrangement of ecological systems – their ecological diversity – influence their capacity to adapt, for example in a context of climate change. The diversity of living systems at any level of organization therefore appears not only as a condition for the short-term sustainability of ecosystems but also as an assurance of their adaptability and evolution over the long term. Consequently, an ecological and evolutionary ethic should give a landmark value to the diverse character of living systems, independently of any human-centred considerations. A fundamental question nevertheless remains, as was clearly expressed by Frankel and Soulé (1981, 7): "If as biologists we accept the proposition that life cannot continue without opportunities for evolution, there remains the question why we should be concerned about the continued existence of living organisms except on grounds of actual or potential use to our own species." This issue is topical for ethics: the long-term existence of the Biosphere could be a biocentric or an anthropocentric target.

Anthropocentric reasons for conserving biodiversity were stated in a very explicit manner in the foreword of the *Global Biodiversity Strategy*, published by international organizations to prepare for the Rio de Janeiro World Conference (Speth et al. 1992). The authors, heads of international organizations, expressed the official consensus prevailing at that time, which considered that the conservation of biodiversity is fundamental to the success of the development process, and that conserving biodiversity is not just a matter of protecting wildlife in nature reserves. They emphasized that conservation is also about safeguarding the natural systems of the earth, which are our life-support systems, as they purify the waters, recycle oxygen, carbon and other essential elements, maintain the fertility of the soil, provide food from the land, freshwaters and seas, yield medicines, and safeguard the genetic richness on which we depend in the ceaseless struggle to improve our crops and livestock.

These arguments are typical of a purely functional view that focuses on what is now called "ecosystem services"[3] (Millennium Ecosystem Assessment 2005), with no explicit evolutionary perspective. Actually, in a more or less detailed manner, and with more or less original examples, many conservationists put forward the present and future services that biodiversity ensures or will provide for humanity's benefit. But they don't answer the question posed by Frankel and Soulé: do we want the biosphere to continue because we value life for itself, or because we believe that the continuation of ecological processes is necessary for humanity's perpetuation in a changing world?

6.6 Uniqueness, Diversity, and Evolutionary Values

On 30 September 1948, at the opening session of the Fontainebleau conference where the IUPN was created, Julian Huxley, the UNESCO general director, evoked "the fascination of all these other manifestations of life which, though all products of the same process of evolution, yet are something in their own rights, are alien from us, give us new ideas of possibilities of life, can never be replaced if lost, nor substituted by products of human endeavour" (reported by Holdgate 1999, 32). In one admirable sentence, Huxley emphasized the diversity of life's manifestations, affirmed that they are alien from us, even if they (and we) are products of a unique history, and recognized that they have rights of their own, that they are definitively unique, and therefore cannot be replaced. In doing so, he revealed the complexity of the ethical issues that nature protectionists have to face.

The notion that all other living creatures – animals, plants, bacteria, and even viruses – being ultimately unique aliens, have their own rights to exist, as Huxley said, stands at the very heart of the debate in environmental ethics. Can we consider the extinction of Ediacara species, 540 millions years ago, from an ethical perspective? Probably not, as nobody was advocating their protection. Considering the eco-evo-dynamics of the biosphere, the death of the last panda – the emblematic endangered species for many conservationists – will have no more consequence for the continuation of the biosphere than the death of the last individual of the dinosaur species had. The transactional web will go on. Nevertheless, if humans have an interest in biosphere history, then each living being should have a value as part of the living memory of past evolution. Therefore, to consider that each living being, and the whole living community, have to be protected "no less than the heritage of our culture" (Ghilarov 2000) is a cultural choice that confers anthropocentric values on living entities. On the other hand, to affirm that any living being has an intrinsic value and warrants respect, as the unique result of a particular trajectory within the evolutionary process, or just because it is a contributor to the transactional web, independently of any human interest, is typical of a biocentric attitude. In some respect, Huxley's view prefigured biocentrism in its later incarnation (Taylor 1986; Rolston 1988). This ethic clearly inspires the first of the "Ten Principles for Conserving Biodiversity" stated in the *Global Biodiversity Strategy* (WRI, IUCN and UNEP 1992): "Every form of life is unique, and warrants respect from humanity."

To recognize that aliens have value independently of humans' interests could be considered as a noble, altruistic effort, a rebuttal to arrogance towards the natural world. But a radical biocentrism could legitimate a radical conservationism, justifying the expulsion of people from their territory to protect a supposedly virgin nature. Some philosophers disagree with such a radical biocentrism. For example, Bryan G. Norton (1988, 201) believes "that species have value as a moral resource to humans, as a chance for humans to form, re-form and improve their own value systems." I think that this statement, which evokes useful relationships between man and other species, bears some similarity to Huxley's suggestion that, being alien from us, other living species offer us different images of life, recalling that man is only one life form among many. This position is evidently anthropocentric, but reflects a wider perspective than the basically utilitarian standpoint, as Norton (1984) has underlined in a previous paper.

An evolutionary perspective cannot consider living beings as only results of the past. Let us express Darwin's fundamental principle as follows: because living beings are different, the adaptability of the systems they form becomes possible through the selection of those that are better adapted than others to new ecological contexts. Therefore, any being, because it differs in some manner from others, has a value for its contribution to adaptability, independently of human-centred considerations. Concrete differences between living beings within any system make this system "bio-diverse." When first formulated, "biodiversity" was just a neologism, a "passe-partout" useful for communication between people (who were not certain that they were speaking about the same thing). Now, even if "biodiversity" is too often considered as a kind of entity, and abusively substituted for nature, it is no more than a collective attribute of any assemblage of living entities that differ from each other. As such, biodiversity can be given a value. More precisely, if we understand that highly biodiverse systems are more adaptive than less biodiverse ones, we can recognize that biodiversity has an "evolutionary value."

Such an approach may have contradictory consequences: in order to avoid the loss of any living being that could contribute to the adaptability of the system it is part of, under circumstances we cannot predict, we should preclude any modification of the present biodiversity. In order to allow change, conservation will refuse any change: should an "evolutionary ethics" favour "fixist" conservation practices? Here, we are at the core of the "substitution problem," which has been brilliantly discussed by Dieter Birnbacher (2004). Let us consider Darwin's principle once again. Under new local conditions, better-adapted entities will continue to contribute to the transactional web, while others will no longer be able to participate and so will disappear. One current view in ecology is that functionally redundant species can exist within an ecosystem, with some species dominant under certain conditions while others replace the former when conditions change. Functional redundancy is a necessary condition for substitutability, and substitutability allows the continuity of ecological processes. This view supports the anthropocentric concept of "ecosystem services continuity" (see for example Millennium Ecosystem Assessment 2005). Nevertheless, some ecologists fight again the redundancy concept; Alexis Ghilarov (2000), for example, argues that each species definitely has a specific array of roles and that redundancy between species concerns only, at best, some roles that they effectively share.

In order to discuss this issue, Birnbacher (2004) opposes both economists and environmentalists: the former tend to consider substitutability to be the rule, the latter the exception. As a matter of fact, approaches to an economic valuation of biodiversity face a dilemma. In France, for example, a group of experts tried such a valuation for the government (Chevassus-au-Louis et al. 2009). They "solved" the dilemma by making a distinction between "exceptional biodiversity," i.e. rare species or ecosystems which cannot be valued (as historical, unique monuments) and "general biodiversity," composed of substitutable species, which produces ecosystem services. Interestingly, these species were valued not one by one (a highly difficult, if not impossible, task) but collectively, by measuring ecosystem services (i.e. timber production, carbon dioxide fixation, etc., by a hectare of an "ordinary" forest).

Consider first the problem of exceptional biodiversity. Rare species are highly valued by conservationists mainly because they are rare (a circular valuation!), perhaps under threat, or even at risk of extinction. In an evolutionary perspective, even if they have no importance for the transactional web, their memory significance should have a consensual value. Nevertheless, as is argued by Birnbacher (2004), historical values cover only a small part of what we value in nature. This is correct; for example, there are different ways of being rare. In many ecosystems, "keystone species," which generally are represented by only a few individuals, play dramatic roles, for example as regulators of various populations. Other species are numerically rare, and of secondary importance for ecosystem functioning, but may be important contributors to evolutionary potential, and perhaps will play essential roles in the future. Think of the discrete mammals "waiting for the extinction of the dinosaurs"... We can therefore value a rare species as a threatened part of life's memory, as a significant contributor to ecological processes, or as a future important player in the web of ecological transactions.

Now let us consider the species that contribute to "general biodiversity." Do species that can substitute for one another have the same value? Is this value linked to the role the species are able to fulfil? Is it linked to the capacity of a given species to substitute for another? In this case, the value of a particular species can change in accordance with the characteristics of the new context provoking the substitution: one context can favour the substitution of species S1 by species S2, while another will favour the substitution of S2 by S1... or by S3, etc. One possibility is to say that the value of a species depends on how many other species it is capable of replacing. If we follow this approach, we will give higher values to generalist species, even to invasive ones. Many conservationists will not agree.

Birnbacher (2004) concluded his philosophical tour through the "substitution problem" by considering relational values, when entities are objects of love, awe, admiration, or some other sentimental attachment. This is a very interesting point. Does that mean that no satisfactory solution can be found to give a rational foundation to the valuation of nature? At this point, I remember the conclusion of Jean Dorst, in his pioneering book *Avant que nature meure* (Dorst 1965). Dorst said that we have enough rational reasons to preserve nature, but nature actually will be preserved if we love it.

6.7 Conclusion

Let me close the circle. Hutchinson (1959, 157), at the end of his so important paper about diversity issues, raised a "metaphysical general point":

> The evolution of biological communities, though each species appears to fend for itself alone, produces integrated aggregates which increase in stability. There is nothing mysterious about this; it follows from mathematical theory and appears to be confirmed to some extent empirically. It is however a phenomenon which also finds analogies in other fields in which a more complex type of behavior, that we intuitively regard as higher, emerges as the result of the interaction of less complex types of behavior, that we call lower. The emergence of love as an antidote to aggression, as Lorenz pictures the process, or the development of cooperation from various forms of more or less inevitable group behavior ... are examples of this from the more complex types of biological systems.

These considerations are in harmony with Thomas Henry Huxley's philosophy, and they are congruent with Leopold's views on the evolution of ethics and also prefigure the hypotheses explored in depth by modern Evolutionary Ethics. Francisco Ayala (2006), for example, argued that the human potential to develop ethics has been shaped by biological evolution, but that our ethics are products of human history, including social and religious traditions. In this context, the construction of Environmental Ethics could be interpreted as a cultural, scientifically inspired process, enhancing humanity's adaptation to the Biosphere. This is obviously the position of Rozzi, who wrote (1999, 920):

> Instead, the interrelations between ecological-evolutionary sciences and environmental ethics can be understood as a dynamically and intimately bonded unit: under this unifying perspective, ecologists and eco-philosophers can overcome the schism between objective knowledge and subjective morality, recovering the link between theory and praxis, between the ways of knowing about nature and the ways of inhabiting the natural world.

Rozzi's reflections support the idea that environmental ethics evolves through a transactional process. Nowadays, the on-going substitution of the "equilibrium paradigm" by the "co-change paradigm" is producing an "eco-evo-ethics," based on the evidence that we live in a permanently changing world. This is a troubling idea: it undermines certainties, and promises no Eden to come. It obliges humans to understand that, while they try to build more stable, more comfortable environments, they always produce change, without being sure that it has any sense. At the same time, they know that they are becoming able to orientate change processes. Because humans are players in the transactional web, the Biocentrism vs. Anthropocentrism debate is obsolete. The aim today should be to organize conviviality with the Biosphere, to create optimal conditions for Man-Nature coevolution: we have to organize the transactional interplay. But can we refer to stable values? Values too are changing through science-ethics transactions. Therefore, perhaps only one eco-evo-ethics principle can be proposed. Written in Leopold's style, it will affirm: "A thing is right when it tends to enhance the Biosphere's capacity to evolve. It is wrong when it tends otherwise." As we occupy some place on Earth, we reduce space for our companion species. At any time, in any place, people will have to make choices. Science will provide tools; respect and love for our coevolving aliens will suggest guidelines.

Notes

1. In 1956, the name was changed to International Union for Conservation of Nature (IUCN).
2. According to Hills (1974), a transaction is a category of interactions which depend not only on the nature of the two elements apparently interacting, but on the nature of a majority (even the totality) of the elements interacting within the whole ecosystem, therefore considered as a "transactional totality." Bergandi (2007) proposed a more global approach and coined the "transactor" concept to characterize the co-changing "unit" formed by any supposed entity and its environment.
3. It is interesting to note that, at the 1948 Fontainebleau conference that created the IUPN, Julian Huxley used the expression "services écologiques officiels" in French in the conference report (UIPN 1949).

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