HALTING BIODIVERSITY LOSS: FUNDAMENTALS AND TRENDS OF CONSERVATION SCIENCE AND ACTION

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Summary

The change and loss of biodiversity are understood as one of the most critical and challenging facets of the currently observed unprecedented anthropogenic change of global ecosystems. In the context of the traditional view shaped by a culture-nature dualism, it is apparent that the most underlying cause of the conservation problems is a phenomenon of the evolution of life on Earth: the origin and expansion of the primate species *Homo sapiens*. It was one of the first and few species to dynamically change the dimensions of its ecological niche. *Homo sapiens* managed to control and change

virtually all types of ecosystems of the world, at an accelerating rate and with increasing effectiveness. The direct consequence was that humans started to be harmful to species not exploited as resources. Among the evolutionary insights is that human action and planning is calibrated to a restricted and easily understandable meso-cosmos evolved as an answer to man's living conditions in the Pleistocene, while the technology allows and achieves development of inestimable large-scale impacts.

Humans are evolutionarily programmed to maximize resource use and individual or horde gains, not to live in an ecologically sustainable way. Thus, conservation can be seen as an attempt at ecological civilizing—heading for a conscious cultural evolution. This chapter describes the origins of conservation, and its changes of motivation and focus. Finally, the recent development of concepts and terms, such as biodiversity, helps overcoming the old man-nature antagonism.

However, as it is becoming ever clearer that the idealized harmony of nature and nature without human impacts do not exist, it is no longer possible to orientate conservation to negative characteristics such as the elimination of human activities. Rather, conservation has to be defined as a cultural concept orientated to the nature and needs of biodiversity, including humans. It is guessed that about 99% of all species that ever lived are extinct today. Several mass extinctions can be distinguished during the evolutionary past. The recent, sixth extinction is caused by spreading humankind. Although it is impossible to provide numbers of species losses, while the total number of existing taxa is unknown, the rate of habitat conversion and loss alone, is unprecedented and an enormous and very rapid loss of biodiversity can be observed.

Ecosystem conversion must not necessarily lead to species loss. Instead, some species benefit from human impacts on their habitat. Thus, human impacts on biodiversity must be analyzed carefully. However, the ongoing ecosystem conversion is a major concern of everyone who is aware of the immeasurable goods and services provided by intact ecosystems. Important examples of stresses to biodiversity and their sources are discussed. Among the most relevant future conservation problems, the accelerated and anthropogenic global climate change is identified. Halting biodiversity loss is among the formally accepted goals of international policy.

Current trends in conservation planning and action are explained. The question of identifying conservation targets and visions is discussed, stressing the importance of considering biological and ecological processes. In conservation science the question of *what* to conserve has been very important. However, increasingly, conservationists feel the need to get a better idea of *how* to conserve. It is claimed that conservation should become more strategic and effective. An important recent trend is the development of an increasingly holistic perspective in conservation planning, taking into account larger dimensions of space and time.

In the framework of different macro-ecological approaches, such as ecosystem management, bioregional or ecoregional management, the conservation objectives are more integral and more ambitious than they used to be in classical conservation visions that focused merely on representation of current patterns of biodiversity at rather small sites. It is of special importance to conserve and enhance biodiversity's adaptability to the impacts of global change processes. Among the important management trends is involving people much more actively in conservation planning and action. A facet of this trend is the increasing role of indigenous peoples and local communities in the management of protected areas, with sharing of decision-making power. The biggest challenge for conservationists is to forge synergy between conservation, maintenance of life support systems and sustainable development.

Conservation of biodiversity as systematic science and action is a very young discipline. Nevertheless, the abundance and diversity of treatments, text books, journal articles and internet resources on this topic is overwhelming and virtually unmanageable. Even in the context of other EOLSS material, biodiversity conservation problems and solutions have already been considered (e.g. Gherardi *et al.* 2004).

Increasingly, change and loss of biodiversity are understood as one of the most critical and challenging facets of the currently observed unprecedented anthropogenic change of global ecosystems. Consequently, many actors and scientists from different continents, cultures and disciplines try to describe, analyse, understand, and abate the problems. The present contribution is a rather brief and summarizing review focussing on frequently neglected aspects of the evolution of biodiversity loss and the culture of the conservation movement.

The understanding of conservation problems and solutions as an evolutionary and cultural issue is significant for the further development of conservation concepts and action. Additionally, some of the latest trends and challenges of biodiversity conservation are described.

1. Culture vs. nature? Biodiversity loss and conservation as facets of human culture and evolution

1.3. Humans as drivers of biodiversity loss—evolutionary roots of conservation problems

Sometimes, in the context of the traditional view shaped by a culture-nature dualism, it is overlooked that the ultimate underlying cause of the conservation problem is a phenomenon of the evolution of life on Earth: the origin and expansion of the primate species *Homo sapiens*. Many conservationists follow a simplified approach that nature is good, and humans are not part of and are generally bad for nature.

Consequently, any biodiversity conservation vision should aim to eliminate the presence and impacts of humans in 'natural' ecosystems. Recognising that this is absolutely impossible, it is challenging to reflect that *Homo sapiens* evolved normally, as all the other species did, under specific historical and environmental conditions.

Today it is practically clear that the human species is an African primate that evolved as an omnivore of open, more or less semiarid vegetation formations. Although it is so basic for understanding our own species and managing the world's conservation problems, many people do not acknowledge that it was in this environment where we acquired our 'human' characters by the means of natural selection. The anatomically modern humans appeared about 100 000 years ago, having evolved as a member of the hominid family. This family, about 5-7 million years ago, diverged from the lineage leading to the chimpanzees. The predecessors of the genus *Homo* are believed to be species of the genus *Australopithecus*; there is a probable direct line from *Australopithecus anamensis* and *A. afaraensis* to *Homo habilis*, *H. erectus* and finally, about 400 000 years BP to *H. sapiens*. *H. erectus* and *H. sapiens*, originally occupied a similar ecological niche. Their evolution was favoured by environmental changes such as a drying climate, the opening of the vegetation in Eastern Africa and the evolution of megaherbivore-rich savannas.

Organized as a social organism, the modern *Homo* species managed to exploit new (meat) food resources shifting to the niche of a hunter of megaherbivores. While more and more breaking into the guild of the carnivores, natural selection forced humans to compensate for lack of weapons and strength by improved communication in the hunting group, the use of technology, and, especially, the controlled application of fire. The use of fire by prehistoric humans, first for purposes such as staying warm, fending off predators, and cooking meat, developed into a history of efficient anthropogenic ecosystem conversion (Williams 2002). This might have happened much earlier than was believed for a long time, in the epoch of *Homo erectus*, about 750,000 years ago.

Probably for more than 90% of the species' life time, *Homo sapiens* lived as a hunter and gatherer. Thus, the human characters evolved and became stabilized in this ecological niche, e.g. physical endurance and related characters such as loss of fur and sweating, taste and diet preferences, the senses and their limitations. This was the time when humans developed the ability to think and plan, in the context of a meso-cosmos of limited dimensions. Natural selection favoured any ability that permitted optimization of the resource use of the group or horde.

There was no need to develop capabilities to feel or foresee long-term or long-distance consequences of their actions. The efficiency of the human resource-use system probably in very early times led to local extinction of food resources. Today it is supposed that *Homo sapiens* contributed to the pleistocenic extinction of many mega-herbivores on all continents, possibly due to overhunting and habitat changes by burning for hunting purposes (Williams 2002).

The problem of local food scarcity was avoided by the excellent migration capacities, possibly related to the acquired technological skills (especially fire management). These skills were well developed even in the times of *Homo erectus* which spread from Africa to Europe and Asia. The mechanism of emigration in order to avoid food scarcity has been an important theme of human history until modern times, finally coming to an end in most continents because most productive ecosystems of the world are populated and utilised. We can, however, still observe population shifts, e.g. from the degraded semiarid tropical Andes towards the humid foothills of the Amazon.

In the early history, when migrating to other ecosystems, even beyond the tropical latitudes, *Homo sapiens*, as one of the first and few species, started to dynamically change the dimensions of its ecological niche. That was something innovative in the course of biological evolution. Other species before *Homo sapiens* had become changers of the structure of the ecosystems they were inhabiting, such as elephants destroying trees and keeping open savannah ecosystems, or competitive trees shading out other species. But those ecosystem converters and changers used to stay, for a rather long time, within a certain geographical and ecological range. *Homo sapiens* managed to control and change virtually all of the Earth's ecosystems, at an accelerating rate and with increasing effectiveness.

A new stage was reached when agriculture was invented. This meant that humans no longer concentrated on the use of wild resources naturally distributed on Earth, and this led to more or less important changes in the ecosystems through reducing the abundance of populations of selected species. With agriculture, humans started to design new ecosystems according to their own needs, leading to a complete change of the ecological niche of the species (Eldredge 2001).

Obviously, humans are not the only ecosystem engineers who change the environment in order to establish adequate habitat conditions; another example is the beaver. However, in the history of evolution the dimensions of intentional ecosystem change implemented by a species, and the subsequent significant and very rapid switch-over of the ecological niche, is unique.

The direct consequence was that humans started to be harmful to species traditionally not exploited as resources. Those species belong to two groups: the organisms that cannot coexist with agroecosystems and others that can but which are combated by the farmers (so-called pests—species that destroy cultivated plants or harm domesticated animals). The most important conservation fact related to the invention of agriculture was that humans and their 'domesticated ecosystems' started to compete for space with 'natural' or 'wild' ecosystems.

Today, the need for agricultural land for a permanently growing human population is the main and ever-increasing reason why man is changing the face of Earth. The expansion of the agricultural frontier is the principal driver of loss of biodiversity and its functions, especially in the most biodiversity-rich regions of the world.

Increasingly, it is claimed that conservation biology should develop a more evolutionary perspective considering that ecological and evolutionary processes are closely related, and that evolutionary responses to anthropogenic environmental change can be very fast and pronounced. A consequent evolutionary conservation approach will take into account the analysis of human evolution. This is important in order to understand, among others, the potential to combat the conservation problems and halt the biodiversity loss. It is important that anyone who tries to promote environmental education should understand the human being as a species with characters conferring adaptation to a pleistocenic environment, and that *Homo sapiens*—without significant evolutionary changes—left his original ecological niche.

The principal cultural problem that conservation is facing is that human action and planning is calibrated to a restricted and easily understandable meso-cosmos while the technology permits inestimable large-scale impacts. It is a trivial statement that humans were not made for a world with globalized environmental problems. "Evolution provided human beings with a nervous system with perceptual constraints that make it hard to deal with slowly developing environmental problems" (Ehrlich & Ehrlich 2004), because it was not required for survival in the pleistocenic African savanna.

Another instructive example that illustrates the evolutionary anachronisms modern humans are facing, is related to human food habits. The pleistocenic humans evolved a permanent appetite to maximize food intake in order to be prepared for the next period of food shortage. Food scarcity was an ever existing selection factor while illness due to obesity was not. As food-shortage has been eliminated in most industrialized countries, over-weight has become one of the most important health problems. Humans are evolutionarily programmed to maximize resource use and individual or horde gains. People do not feel the need to restrict food intake, and they do not feel the need to manage natural resources in a sustainable way. They are programmed to eat and use as much as they can. This makes both nutrition and environmental education so difficult.

Fortunately, humans developed an intellectual flexibility to learn how to control or to rationally change certain attitudes and habits, if personal advantages are expected as outcomes. On the one hand, we can never rely on humans to have a natural feeling for sustainability, but, on the other hand, there is a potential for a process of ecological civilizing or maybe even a conscious cultural evolution (Ehrlich & Ehrlich 2004).

Perhaps the only logical strategy is that we make individuals and societies understand that they can earn a (a rather short-term) net gain. On a rational level, the cultural evolution has started development of the concept of biodiversity conservation. However, since the individual humans tend to prioritize their short-term well- (and better-) being, it is much easier to get a broad support for measures that enhance immediate economic growth than for activities that safeguard resources required by future generations.

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Bibliography

Note: The manuscript is based on almost three hundred references referring to original research or reviews. Due to the encyclopedic character of the EOLSS contributions, it is not possible to include all of them in the bibliography. However, a complete reference list can be provided by the authors. In the following, we give a list of recommended publications - especially in English language - that facilitate further comprehension of relevant topics.

ACIA (2004). *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*. Cambridge University Press, Cambridge, UK. [Report of a comprehensively researched, fully referenced evaluation of arctic climate change and its impacts for the region and for the world]

Alcamo, J. *et al.* 2003. *Ecosystems and human well-being: a framework for assessment.* Millennium Ecosystem Assessment. World Resources Institute. [First volume of the Millennium Ecosystem Assessment, a four-year international work program designed to meet the needs of decision-makers for scientific information on the links between ecosystem change and human well-being. The Millennium Assessment focuses on how humans have altered ecosystems, and how changes in ecosystem services have affected human well-being, how ecosystem changes may affect people in future decades, and what types of responses can be adopted at local, national, or global scales to improve ecosystem management and thereby contribute to human well-being and poverty alleviation]

Allesina, S., and Bodini, A. (2004). Who dominates whom in the ecosystem? Energy flow bottlenecks and cascading exctinctions. *Journal of Theoretical Biology* **230**, 351-358. [Investigates the problem of secondary extinction in food webs through the use of dominator trees, network topological structures that reduce food webs to linear pathways that are essential for energy delivery.]

Alroy, J. (2001). A multispecies overkill simulation of the end-Pleistocene megafaunal mass extinction. *Science* **292**, 1893-1896. [Presents a fully mechanistic model that accounts for megafaunal extinction without invoking climate change and secondary ecological effects]

Anonymus (2004). Ignorance is not a bliss. *Nature* **430**, 385. [Nature editorial text complaining about the relative ignorance of biodiversity scientists especially when compared to other disciplines such as climate change specialists who managed to receive more public awareness and support for filling in knowledge gaps]

Baillie, J. E. M., Hilton-Taylor, C., and Stuart, S. N., eds. (2004). *2004 IUCN Red List of Threatened Species. A Global Species Assessment.* IUCN, Gland, Switzerland and Cambridge, UK. [Provides global assessments of the status of species and other taxa to highlight those threatened with extinction years]

Balmford, A., R.E. Green, and M. Jenkins (2003). Measuring the changing state of nature. *Trends Ecol. Evol.* **18**: 326-330. [Investigation of large-scale measures of the changing state of nature, focusing on recent analyses of trends in population size, numbers of populations and habitat extent]

Bambach, R. K., Knoll, A. H., and Sepkoski Jr., J. J. (2002). Anatomical and ecological constraints on Phanerozoic animal diversity in the marine realm. *Proceedings of the National Academy of Sciences* **99**, 6854-6859. [Presents the results of a study indicating the importance of ecological structure in constraining taxonomic richness through time]

Barnosky, A. D., Bell, C. J., Emslie, S. D., Goodwin, H. T., Mead, J. I., Repenning, C. A., Scott, E., and Shabel, A. B. (2004b). Exceptional record of mid-Pleistocene vertebrates helps differentiate climatic from anthropogenic ecosystem perturbations. *PNAS* **101**, 9297-9302. [analyzing >20,000 mammal fossils in relation to modern species and independent climatic proxies, the authors conclude that climatic warming primarily affected mammals of lower trophic and size categories, in contrast to documented human impacts on higher trophic and size categories historically]

Bennett, A.F. 1999. *Linkages in the landscape. The role of corridors and connectivity in wildlife conservation.* IUCN, Gland/Cambridge. [An information source for practitioners who are grappling with the question of how wildlife can be conserved within developed landscapes]

BirdLife International, B. (2004). State of the world's birds: Numerous species have been driven extinct, Vol. 2004. [This assessment examines what birds can tell us about the state of biodiversity, the pressures upon it and the solutions that are being, or should be, put in place]

Bowman, D.M.J.S. (1998). Death of biodiversity - the urgent need for global ecology. *Global Ecology and Biogeography Letters* **7**, 237-240. [The author recommends development of an intellectually rigorous global ecology as planetary health requires management of entire ecosystems and the maintenance of biogeochemical cycles]

Bowring, S. A., Erwin, D. H., and Isozaki, Y. (1999). The tempo of mass extinctions and recovery: The end-Permian example. *Proceedings of the National Academy of Sciences* 96, 8827-8828. [Summary of a session presented at the first Japanese-American Frontiers of Science symposium, held August 21–23, 1998, in CA, discussing tempo of and recovery after the end-Permian extinction]

Briers, R.A. (2002). Incorporating connectivity into reserve selection procedures. *Biological Conservation* **103**, 77-83. [Presentation of iterative reserve selection algorithms which incorporate considerations of reserve connectivity and evaluate their performance using a data set for macroinvertebrates in ponds]

Brooks, T., A. Balmford, N. Burgess, J. Fjeldså, L.A. Hansen, J. Moore, C. Rahbek, and P. Williams (2001). Toward a blueprint for conservation in Africa. *BioScience* **51**, 613-624. [Presents a data-driven biodiversity analysis method for conservation prioritzation in sub-Saharan Africa]

Bruner, A.G., R.E. Gullison, R.E. Rice, and G.A.B. da Fonseca (2001). Effectiveness of parks in protecting tropical biodiversity. *Science* **291**, 125-128. [Impacts of anthropogenic threats on 93 protected areas in 22 tropical countries are assessed to test the hypothesis that parks are an effective means to protect tropical biodiversity]

Bush, M.B. 1994. Amazonian speciation: a necessarily complex model. *Journal of Biogeography* 21: 5-17. [Highlights the species range shifts in glacial times when, e.g., typical Andean species invaded the Amazon lowlands coexisting with lowland-tropical elements]

Cardillo, M. (2003). Biological determinants of extinction risk: Why are smaller species less vulnerable? *Animal Conservation* **6**, 63-69. [Data for the Australian terrestrial mammal fauna are used to ask whether higher reproductive output or smaller home ranges can explain the reduced extinction risk of species that are smaller in body size]

Cardillo, M., and Bromham, L. (2001). Body Size and Risk of Extinction in Australian Mammals. *Conservation Biology* **15**, 1435-1440. [Using a combination of randomization tests and phylogenetic analyses the link between body size and risk of extinction in Australian mammals has been analysed]

Catlin, G. (1841). *Letters and notes on the manners, customs, and conditions of the North American Indians.* New York. [A historical pioneer document suggesting the establishment of protected areas]

Chapin III, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., Hooper, D. U., Lavorel, S., Sala, O. E., Hobbie, S. E., Mack, M. C., and Diaz, S. (2000). Consequences of changing biodiversity. *Nature* **405**, 234-242. [Based on a discussion of the changes of biodiversity following global change effects and resulting consequences the authors propose a set of recommendations for action]

Cohen, J. E. (2003). Human population: The Next half century. *Science* **302**, 1172-1175. [Presents demographic projections until 2050 and discusses demographic uncertainties]

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neill, J. Paruelo, R. Raskin, P. Sutton & M. van den Belt (1997): The value of the world's ecosystem services and natural capital. *Nature* **38**, 253-260. [Estimation of the current economic value of 17 ecosystem services for 16 biomes, based on public studies and a few original calculations]

Crutzen, P. J. (2002). Geology of mankind. *Nature* **415**, 23. [The author explains the term 'anthropocene' and summarizes changes this geological epoch has brought up]

Daily, G.C., S. Alexander, P.R. Ehrlich, L. Goulder, J. Lubchenco, P.A. Matson, H.A. Mooney, S. Postel, S.H. Schneider, D. Tilman, and G.M. Woodwell (1997): *Ecosystem services: benefits supplied to human societies by natural ecosystems.* Issues in Ecology #2. Ecological Society of America, Washington DC. [Summarizes scientific evidence to proove the importance of ecosystem services for human well-being and discusses anthropogenic impacts on their delivery]

Ehrlich, P. R. (2001). Intervening in evolution: Ethics and actions. *PNAS* **98**, 5477-5480. [The author discusses how biologists can help to guide a process of cultural evolution in which society determines how much effort, if any, is ethically required to preserve options in biological evolution]

Ehrlich, P., and Ehrlich, A. (2004). *One with Nineveh: Politics, consumption, and the human future.* Island Press, Washington. [Analysis of current knowledge in diverse topics related to sustainability such as ecology, demographics, migration, economics, biodiversity, ethics, climate, politics and globalization with proposed measures towards achieving a sustainable world]

Eldredge, N. (2001). New frontiers: The sixth extinction, Vol. 2004. ActionBioscience, American Institute of Biological Sciences. [A compilation and description of the most important extinction events of the Earth's history highlighting the fact that the current anthropogenic extinction phase is the first to be caused by a single biotic factor]

Erwin, D. H. (1998). The end and the beginning: recoveries from mass extinctions. *Trends in Ecology and Evolution* **13**, 344-349. [This article looks at the interdependencies between processes of survival and recovery of species after an extinction event and the patterns of extinction itself]

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., and Holling, C. S. (2004). Regime shifts, resilience and biodiversity in ecosystem management. *Annual Review in Ecology, Evolution and Systematics* **35**, 557-581. [Reviews the evidence of regime shifts in terrestrial and aquatic environments in relation to resilience of complex adaptive ecosystems and the functional roles of biological diversity in this context]

Frankham, R., Jonathan D. Ballou, David A. Briscoe (2004). *An introduction to conservation genetics.* Cambridge University Press, Cambridge. [A first standard text book summarizing recent findings and important fundamentals of this new sub-discipline of conservation biology]

Gherardi, F., C. Corti, M. Gualtieri (2002). Biodiversity conservation and habitat Management, in Encyclopedia of natural resources policy and management, in Encyclopedia of Life Support Systems (EOLSS), developed under the auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net].

Gnaiger, E. (1992). Evolutionärer Naturschutz und Naturbegriff. Nationalparkplanung mit konstruktiven Widersprüchen. In Umwelt und Tourismus (E. Gnaiger and H. Kautzky, eds.), pp. 67-80. Kulturverlag, Thaur, Umweltforum Innsbruck. [Proposes the interesting concept of evolutionary conservation based in the fact that the human species is a product of biological evolution and therefore conservation must not exclude humans or defend non-human biodiversity from human action; moreover, conservation is seen as a cultural concept that needs to consider the natural dynamics rather than concentrate on a static protection approach]

Grayson, D. K., and Meltzer, D. J. (2002). Clovis Hunting and Large Mammal Extinction: A Critical Review of the Evidence. *Journal of World Prehistory* **16**, 313-359. [Outcomes of an analysis of Clovis-age archaeological associations with now-extinct mammals]

Groves, C. R. (2003). Drafting a conservation blueprint. A practitioner's guide to planning for biodiversity. The Nature Conservancy. [Useful resource for conservation planning practitioners focusing on concepts and tools developed by The Nature Conservancy]

Grumbine, R.E. 1994. What is ecosystem management? *Conservation Biology* **8**: 27-38. [On the historical development of ecosystem management, providence of a working definition and summary of dominant themes taken from an extensive literature review]

Hannah, L., Midgley, G. F., Lovejoy, T., Bond, W. J., Bush, M., Lovett, J. C., Scott, D., and Woodward, F. I. (2002) Conservation of Biodiversity in a Changing Climate. *Conservation Biology* **16** (1), 264-268. [Reviews studies on climate change and discusses conservation responses to limit the damage]

Heim, R. (1952). *Destruction et protection de la nature*. Armand Colin, Paris. [Historical source cited for the purpose of highlighting the European conservation terminology]

Hockings, M., Stolton, S., and Dudley, N. (2000). *Evaluating Effectiveness: A Framework for Assessing the Management of Protected Areas*. IUCN, Gland, Switzerland and Cambridge, UK. [Describes theoretical and methodological aspects of the framework and demonstrates its practical application on six case studies]

Hughes, J. B., Daily, G. C., and Ehrlich, P. R. (1997). Population diversity: its extent and extinction. *Science* **278**, 689-692. [This work estimates the number of populations per area of a sample of species from literature on population differentiation and the average range area of a species from a sample of distribution maps]

IPCC, ed. (2001). *Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK. [The most comprehensive and up-to-date scientific assessment of past, present and future climate change]

Jablonski, D. (1991). Extinctions: A paleontological perspective. *Science* **253**, 754-757. [Extrapolations of extinction intensities, as well as discussion of extinction patterns and recovery intervals]

Jablonski, D. (2001). Lessons from the past: Evolutionary impacts of mass extinctions. *Proceedings of the National Academy of Sciences* **98**, 5393-5398. [Looking at evolutionary effects of mass extinctions the author asks which lessons from the past can be learned that transcend the specific mechanisms, intensities, and participants of earlier events]

Jablonski, D. (2004). Extinction: past and present. *Nature* **427**, 589. [Discusses how fossil record, together with modern data, can provide a deeper understanding of biological extinction and its consequences]

Jennings, M.D. 2000. Gap analysis: concepts, methods, and recent results. *Landscape Ecology* **15**, 5-20. [Useful introduction to the important sub-discipline of conservation planning that concentrates on the systematic analysis of biodiversity representation in protected areas]

Kareiva, P. and M. Marvier (2003). Conserving biodiversity coldspots. *American Scientist* **91**, 344-351. [Challenging view that questions the widespread hot spot approach developed by the conservation NGO Conservation International highlighting the conservation importance of ecosystems that do not belong the most species or endemism-rich and threatened ones]

Kates, R. W., Turner III, B. L., and Clark, W. C. (1990). The great transformation. In: The earth as transformed by human action. Global and regional changes in the biosphere over the past 300 years. (B. L. Turner III, W. C. Clark, R. W. Kates, J. F. Richards, J. T. Mathews and W. B. Meyer, eds.), pp. 1-17. Cambridge University Press, Cambridge, UK. [One of the first systematic treatments dealing with anthropogenic global environmental change, among others, providing a historical overview]

Kerr, R. R. (2001a). Mass extinctions face downsizing, extinction. *Science* **293**, 1037. [Kerr comments on latest paleontologic insights leaving doubt on the true magnitude of two of the five historic mass extinction events]

Kerr, R. R. (2001b). Paring down the big five mass extinctions. *Science* **294**, 2072-2073. [Study identifying the need for further research on the scale and existence of mass extinctions]

Kothari, A. (2004). Protected areas and people: participatory conservation. In Biodiversity issues for consideration in the planning, establishment and management of protected area sites and networks (Secretariat of the Convention on Biological Diversity, ed.), pp. 94-99, CBD, Montreal (CBD Technical Series no. 15). [Describes the importance of participatory conservation and provides guidelines on how to implement a participatory conservation concept]

Leakey, R. E., and Lewin, R. (1996). *The Sixth Extinction: pPatterns of life and the future of humankind*. Anchor Books, Doubleday. [A powerful message based on years of observation and fieldwork calling for a drastic change in the ways in which we impact on the environment]

Levin, P.S. & B.F. Kochin (2004). Publication of marine conservation papers: Is conservation biology too dry?. *Conservation Biology* **18** (4), 1160-1162. [Review of and discussion on the unbalanced relation between published articles on marine and terrestrial ecosystems in scientific journals]

Loreau, M., N. Mouquet, and R.D. Holt (2003). Meta-ecosystems: a theoretical framework for a spatial ecosystem ecology. *Ecology Letters* **6,** 673-679. [This contribution proposes the meta-ecosystem concept as a natural extension of the metapopulation and metacommunity concepts]

Margules, C.R. & R.L. Pressey (2000). Systematic conservation planning. *Nature* **405**, 243-253. [Calls for implementation of a more systematic approach to locating and designing reserves in order to maintain a large proportion of currently existing biodiversity]

Margules, C.R., N.O. Nicholls, and R.L. Pressey (1988). Selecting networks of reserves to maximize biological diversity. *Biological Conservation* **43**. 63-76. [Two algorithms are presented which define the smallest number of wetlands on the Macleay Valley floodplain, Australia, which include all of the wetland plant species]

Marijnissen, C., Ozinga, S., Richards, B., and Risso, S. (2004). Facing reality: how to halt the import of illegal timber in the EU (FERN, Greenpeace European Unit, WWF European Policy Office, eds.), 38pp. [To support successful implementation of the EU Action Plan on Forest Law Enforcement, Governance and Trade (FLEGT), FERN, Greenpeace and WWF provide recommendations to EU policy makers]

Marsh, G.P. (1864). Man and nature; or, physical geography as modified by human action. C. Scribner, New York (http://lcweb2.loc.gov/cgibin/query/r?ammem/consrv:@field(DOCID+@lit(amrvgvg07)):@@@REF). [Historical reference representing a pioneering and visionary analysis of human impact on nature]

Massart, J. (1912). *Pour la protection de la nature en Belgique*. Éditions Lamertin, Bruxelles. [Historical source cited for the purpose of highlighting the European conservation terminology]

McKee, J.K., Sciulli, P.W., Fooce, C.D., and Waite, T.A. (2003). Forecasting global biodiversity threats associated with human population growth. *Biological Conservation* **115**, 161-164. [The article presents outcomes of modelling of the relationship between human population density and the number of threatened mammal and bird species by nation]

Miller, K. (1995). *Balancing the scales: managing biodiversity at the bioregional level. World Resource Institute.* Washington, DC. [Description of the concept of bioregional conservation as a macro-ecological approach that aims at the conciliation of conservation planning and satisfying human needs]

Miller, K. (1999). Bioregional planning and biodiversity conservation. In Partnerships for protection. New strategies for planning and management for protected areas (S. Stolton, and N. Dudley, eds.), pp. 41-49, Earthscan Publications, London. [Further explanation of the bioregional conservation approach that shares common elements with the concept of the Biosphere Reserves]

Miller, K., M. H. Allegreth, N. Johnson, and B. Jonsson (1995). Measures for conservation of biodiversity and sustainable use of its components. In Global biodiversity assessment (UNEP, ed.), pp. 915-1061, Cambridge University Press. Cambridge. [An important compilation of the 1990s state of the art of conservation measures fully recognizing the systemic characteristics of biodiversity and its threats, giving a proper weight to aspects of functionality and environmental change]

Milner-Gulland, E. J. (2004). Taking stock of conservation. *Nature* **429**, 346 – 347. [Review of W.M. Adams' book 'Against Extinction: The Story of Conservation']

Mulongoy, K.J. and S. Chape (eds) (2004). *Protected areas and biodiversity. An overview of key issues.* CBD, UNEP-WCMC. [A synthesis of issues relating to protected area planning, establishment and management for CBD Parties, decision makers, and other stakeholders]

Myers, N. (1996). Environmental services of biodiversity. *PNAS* **93**, 2764-2769. [Summary assessment of several categories of environmental services, giving a brief overview of economic values at issue and an appraisal of the implications for conservation planning]

Myers, N. (1997). ECOLOGY: Mass extinction and evolution. *Science* **278**, 597-598. [Discusses the grossly disruptive impact of the sixth extinction on the future course of evolution]

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* **403**, 853-858. [The biodiversity hotspots concept is presented as one possible way to assist most species under threat at the least cost]

Norse, E. A., and McManus, R. E. (1980). Ecology and living resources: biological diversity. In Environmental quality 1980: the eleventh annual report of the Council on Environmental Quality. (Council on Environmental Quality, ed.), pp. 31-80, Washington, D.C. [Historical reference introducing and explaining the term biological diversity]

Norse, E. A., Rosenbaum, K. L., Wilcove, D. S., Wilcox, B. A., Romme, W. H., Johnston, D. W., and Stout, M. L. (1986). *Conserving biological diversity in our national forests.* The Wilderness Society, Washington, D.C. [Historical reference explaining the term and concept of biological diversity]

Noss, R.F. 2001. Beyond Kyoto: forest management in a time of rapid climate change. *Conservation Biology* **15**, 578-590. [Review of properties of forest ecosystems and management options for enhancing the resistance and resilience of forests to climate change]

Noss, R. & Soulé, M. (1998). Rewilding and biodiversity: complementary goals for continental conservation. *Wild Earth* **#Fall 1998**, 1-11. [A plea for rewilding ecosystems restoring them and making possible, among others, the reintroduction of large carnivores that went extinct]

Olson, D. and E. Dinerstein (1999). The Global 200 Initiative: a representation approach to conserving the earth's distinctive ecoregions. In Partnerships for protection. New strategies for planning and management for protected areas (Stolton, S. & N. Dudley, eds.), pp. 59-68, Earthscan Publications, London. [Description of the WWF macro-ecological approach to global conservation aiming at an adequate representation of the Earth's biodiversity that is based on relatively large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions]

Pagiola, S., J. Bishop & N. Landell-Mills (eds.) (2002): *Selling forest environmental services. Market-based mechanisms for conservation and development.* Earthscan, London, UK. [Practical and utilitarian approach to forest conservation by giving economical value to forest ecosystems' services. The book describes the contract mechanism developed for the Regional Integrated Silvopastoral Ecosystem Management Project, which is being implemented with financing from the Global Environment Facility (GEF). The project is testing the use of the payment-for-service mechanism to encourage the adoption of silvopastoral practices in three countries of Central and South America: Colombia, Costa Rica, and Nicaragua. The project has created a mechanism that pays land users for the global environmental services they are generating, so that the additional income stream makes the proposed practices privately profitable]

Parmesan, C., and Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature* **421**, 37-42. [Based on debates on whether or not climate change already influences natural systems, diverse analyses have been applied to more than 1,700 species and results are presented]

Payne, J. L., Lehrmann, D. J., Wei, J., Orchard, M. J., Schrag, D. P., and Knoll, A. H. (2004). Large Perturbation of the Carbon Cycle during the Recovery from the End-Permian Extinction. *Science* **305**, 506-509. [The article presents and discusses results from high-resolution carbon isotope measurements of multiple stratigraphic sections in south China]

Pimm, S. L., and Raven, P. (2000). Extinction by numbers. *Nature* **403**, 843-845. [Comments the Nature article by Myers et al. (2000) which presents the hotspots concept and supports it with further results from studies on the rapid decline of biodiversity]

Pressey, R.L. (2001). Conservation planning – a young science playing in the big league. Society for Conservation Biology Newsletter Vol. 8 (4), Nov. 2001, 2-3 (http://www.conbio.org/Publications/Newsletter/Archives/2001-4-November/8-4__004.Cfm). [Plea for standards for conservation planning written by one of the most experienced conservation planning scientists who wisdoms how the field of systematic conservation planning has matured considerably since the 1980s]

Pressey, R.L. and R.M. Cowling (2001). Reserve selection algorithms and the real world**.** *Conservation Biology* **15,** 275-277. [Defense of algorithms against criticism put forward by another author claiming that these do not facilitate conservation planning in a real world where conservation is subject to many social, economic and political constraints]

Raup, D. M. (1991). *Extinction: Bad genes or bad luck?* W. W. Norton & Company, New York. [The question whether species go extinct due to some weakness or because they were in the wrong place at the wrong time is discussed using historic and prehistoric examples]

Raup, D. M. (1994). The role of extinction in evolution. *Proceedings of the National Academy of Sciences* **91**. [Reviews records of extinction as well as episodes and the leads over to discuss the issue of selectivity and effects of selectivity in extinction events]

Rodrigues, A.S., S.J. Sandy J. Andelman, M.I. Bakarr, L. Boitani, T.M. Brooks1, R.M. Cowling, L.D.C. Fishpool, G.A.B. da Fonseca, K.J. Gaston, M. Hoffmann. J.S. Long, P.A. Marquet, J.D. Pilgrim, R.L. Pressey, J. Schipper, W. Sechrest, S.N. Stuart, L.G. Underhill, R.W. Waller, M.E.J. Watts, and Xie Yan (2004b). Effectiveness of the global protected area network in representing species diversity. *Nature* **428**, 640-643. [Five global data sets on the distribution of species and protected areas are combined to provide the first global gap analysis assessing the effectiveness of protected areas in representing species diversity]

Root, T.L., Price, J.T., Hall, K.R., Schneider, S.H., Rosenzweig, C., and Pounds, J.A. (2003). Fingerprints of global warming on wild animals and plants. *Nature* **421**, 57-60. [Information on species and global warming has been gathered from 143 studies and used in a meta-analyses revealing a consistent temperature-related shift]

Rosenzweig, M.L. (2003). *Win-Win Ecology: How earth's sSpecies can survive in the midst of human eEnterprise*. Oxford University Press, New York, USA. [Based on his definition of reconciliation ecology the author presents the potential of this discipline for conserving large parts of the world's biodiversity]

Rouget, M., Cowling, R.M., Pressey, R.L., and Richardson, D.M. (2003). Identifying spatial components of ecological and evolutionary processes for regional conservation planning in the Cape Floristic Region, South Africa. *Diversity and Distributions* **9**, 191-210. [Results of a study in which spatial components were identified in a GIS and options for achieving targets for process components have been compromised by habitat transformation]

Sarkar, S. (2004). Conservation Biology. In The Stanford Encyclopedia of Philosophy *(Winter 2004 Edition)* (Edward N. Zalta, ed.), URL = <http://plato.stanford.edu/archives/win2004/entries/conservation-biology/>.

Secretariat of the Convention on Biological Diversity (2004). Status and trends of, and threats to, protected areas. In Biodiversity issues for consideration in the planning, establishment and management of protected area sites and networks (Secretariat of the Convention on Biological Diversity, ed.), pp. 31-36, CBD, Montreal (CBD Technical Series no. 15). [Touches the issues on coverage of protected areas, protected area effectiveness, IUCN Management Categories as well as threats to protected areas]

Sekercioglu, C. H., Daily, G. C., and Ehrlich, P. R. (2004). Ecosystem consequences of bird declines. *PNAS* **101**, 18042-18047. [This paper presents a general framework for characterizing the ecological and societal consequences of biodiversity loss and applying it to the global avifauna]

Shafer, C.L. (1999). National park and reserve planning to protect biological diversity: some basic elements. *Landscape and Urban Planning* **44**, 123-153. [Key needs for the creation of a nature reserve system are outlined (e.g. formulating goals, selecting management categories, measuring reserve condition and vulnerability), and some essential components are highlighted]

Solé, R. V., and Newman, M. (2002). Extinctions and biodiversity in the fossil record. In Encyclopedia of global environmental change (H. A. Mooney and J. G. Canadell, eds.), pp. 297-301. John Wiley & Sons, Ltd, Chichester. [Summarizes the extinction and radiation events of the geological eras based on latest insights from scientific studies and discusses possible biases in the fossil record as well as clear trends that can be identified]

Soulé, M. E. (1985). What is Conservation Biology? *BioScience* **35,** 727-734. [Early publication at the beginning of a new era of conservation and starting point of modern conservation science]

Soulé, M. E., ed. (1986). *Conservation Biology. The science of scarcity and dDiversity.* Sinauer, Sunderland, MA. [Early publication at the beginning of a new era of conservation and starting point of modern conservation science]

The Nature Conservancy (2003). The Five-S framework for site conservation: A practitioner's handbook for site conservation planning and measuring conservation success. Vol. 1, 2nd edition, The Nature Conservancy. [Sets forth a framework for site-based conservation, including strategic conservation planning and assessing measures of conservation success]

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., Siqueira, F. d., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A. S., Midgley, G. F., Miles, L., Ortega-Huerta, M. A., Townsend Peterson, A., Phillips, O. L., and Williams, S. E. (2004a). Extinction risk from climate change. *Nature* **427**, 145-148. [Exploring three approaches in which the estimated probability of extinction shows a powerlaw relationship with geographical range size, the authors predict species extinction rates on the basis of mid-range climate-warming scenarios for 2050]

Thomas, J. A., Telfer, M. G., Roy, D. B., Preston, C. D., Greenwood, J. J. D., Asher, J., Fox, R., Clarke, R. T., and Lawton, J. H. (2004b). Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science* **303**, 1879-1881. [Presents a comparison at the national scale of population and regional extinctions of birds, butterflies, and vascular plants from Britain in recent decades]

UNEP (2002). *Global Environmental Outlook 3*. Earthscan Publications Ltd., London, United Kingdom. [The United Nations Environment Programme has once again fulfilled its cardinal responsibility to present, in clear, accessible terms, the challenges we face in safeguarding the environment and moving towards a more sustainable future]

UNEP (2000). Decisions of the COP5 of the Convention on Bilogical Diversity. V/6: Ecosystem approach (Online: http://www.biodiv.org/decisions/default.asp?lg=0&m=cop-05&d=06). [Presents the COP decisions on the ecosystem approach, describes the approach itself and outlines its' principles]

UNEP-WCMC, WCPA & IUCN (2003). United Nations List of Protected Areas (http://sea.unep-wcmc.org/wdbpa/unlist/2003_UN_LIST.pdf). [The first version to attempt a comprehensive presentation of all the world's known protected areas listing 102,102 sites covering 18.8 million km^2]

van Loon, A. J. (2003). The dubious role of man in a questionable mass extinction. *Earth-Science Reviews* 62, 177-186. [Sheds light on extinction, evolution and anthropogenic influences on these natural events from an angle that is contrary to the most common one]

Visscher, H., Looy, C. V., Collinson, M. E., Brinkhuis, H., van Konijnenburg-van Cittert, J. H. A., Kürschner, W. M., and Sephton, M. A. (2004). Environmental mutagenesis during the end-Permian ecological crisis. *Proceedings of the National Academy of Sciences* 101, 12952-12956. [Investigates mutations in lycopsid microspores at the end-Permian and discusses raised UV stress as a consequence of severe disruption of the stratospheric ozone balance as a possible root cause]

Wackernagel, M., and Rees, W. (1996). *Our Ecological Footprint: Reducing Human impact on the earth*. New Society Publishers, Philadelphia, PA. [A new approach to quantify the carrying capacity of the planet, and the overshoot of the current use of natural resources]

Walter, H.S. (2004). The mismeasure of islands: implications for biogeographcial theory and the conservation of nature. *Journal of Biogeography* **31**, 177-197. [This paper re-examines concepts and biogeographical evidence from a geographical rather than ecological or evolutionary perspective]

Webster, D. (1997). The Looting and Smuggling and Fencing and Hoarding of Impossibly Precious, Feathered and Scaly Wild Things. In New York Times Magazine, p. 28.

Wignall, P. B., and Benton, M. J. (1999). Lazarus taxa and fossil abundance at times of biotic crisis. *Journal of the Geological Society, London* **156**, 453-456. [Tests whether the Lazarus effect is attributed to a poor-quality fossil record or migration to refuges with examples from the end Permian and late Triassic extinctions and presents the results]

Williams, M. (2002). Deforesting the Earth: from prehistory to global crisis. The University of Chicago Press, Chicago. [A standard text book on deforestation on all continents covering the whole human history]

Wright, R. G., and Mattson, D. J. (1996). The origin and purpose of national parks and protected areas. In National parks and protected areas. Their role in environmental protection. (R. G. Wright, ed.), pp. 3-14. Blackwell Science. [Review of history of protected areas and their tasks]

WWF (2004). How effective are protected areas? WWF, Gland, Switzerland. 24 pp. [The report outlines preliminary results from the first application of a tracking tool to provide an assessment of effectiveness in individual protected areas, developed by WWF in cooperation with the World Bank and the World Commission on Protected Areas]

WWF, UNEP, WCMC, and Global Footprint Network (2004). Living Planet Report 2004. WWF, Gland, Switzerland. [Latest of the Living Planet publication series which explore the impact of man on this planet based on the Living Planet Indicator and the Ecological Footprint]

WWF, UNEP, WCMC, and CSS (2002). Living Planet Report 2002. WWF, Gland, Switzerland. [The fourth in the series of Living Planet publications; see above]

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Pierre L. Ibisch (Prof. Dr. habil.) is currently a professor for Nature Conservation with the University of Applied Sciences Eberswalde, Germany. He trained as a biologist with experience in basic research related to botany, biodiversity and taxonomy at the at the Rheinische Friedrich-Wilhelms University in Bonn, Germany (Prof. W. Barthlott). As a conservation scientist he started to work in Bolivia, South America, where he lived for almost 9 years (between 1991 and 2003). As a consultant he was involved in a rural development project developing an agroforestry concept and promoting environmental education, as well as the cooperation and networking of environmental NGOs. After gathering work experience in Germany, among others, analysing the contribution of Botanical Gardens to biodiversity conservation, he became an expert of the German development cooperation supporting Bolivia's largest conservation NGO (Fundación Amigos de la Naturaleza, FAN). As head of the Sciences Department of FAN, e.g. he developed methodologies for ecoregional conservation planning in Bolivia and was involved in biodiversity and conservation policy. He was adviser of the Bolivian government supporting the formulation of the Bolivian biodiversity strategy. He is the author of many scientific papers and books (in English, Spanish and German); among others, he is the principal editor and author of the first monograph on biodiversity and conservation in Bolivia.

Monika Bertzky studied biology (M.Sc.) from 1998 to 2003 at the Rheinische Friedrich-Wilhelms University in Bonn, Germany. Her main fields of activity are biodiversity, tropical ecology and conservation science, with working experiences in Tanzania, Bolivia, Cuba, and Thailand. By the beginning of 2004 she has been working as lecturer in international study courses at the University of Applied Sciences Eberswalde, Germany. Since July 2004 she has been working as a PhD candidate in an interdisciplinary project (GoBi – Assessing Biodiversity Governance and Management Approaches) at the Humboldt University of Berlin, Germany (www.biodiversitygovernance.de). Within the project she is now dealing with the integration of scientific and qualitative social research in the face of biodiversity management effectiveness.