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

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Keywords: Conservation, biodiversity conservation, protection, biodiversity loss, extinction, anthropocene, threats, carrying capacity, ecological footprint, priority setting, conservation targets, conservation visions, conservation strategies, ex-situ conservation, in-situ conservation, protected areas, protected area management, gap analysis, climate change.

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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 semi-arid 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 pleistocene extinction of many megaherbivores 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 semi-arid 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 pleistocene African savanna.

Another instructive example that illustrates the evolutionary anachronisms modern humans are facing, is related to human food habits. The pleistocene 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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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.

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Anonymous (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]


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]


considerations of reserve connectivity and evaluate their performance using a data set for macroinvertebrates in ponds]


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]


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]


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]


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]


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]


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]


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]


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]


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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]


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.]


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.]


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**Biographical Sketches**

**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.