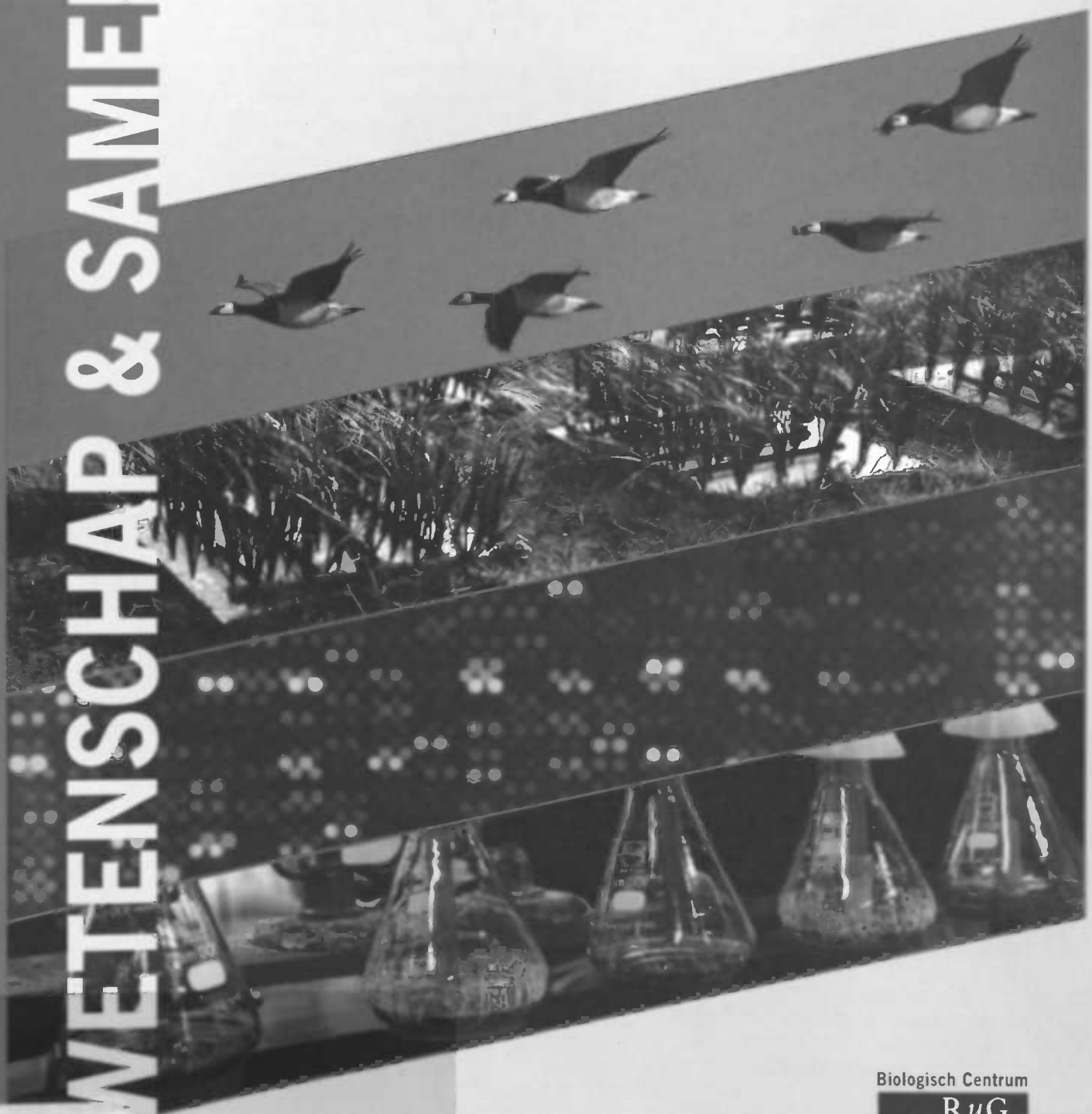
WETENSCHAP & SAMENLEVING

Reconnecting Nature and Man

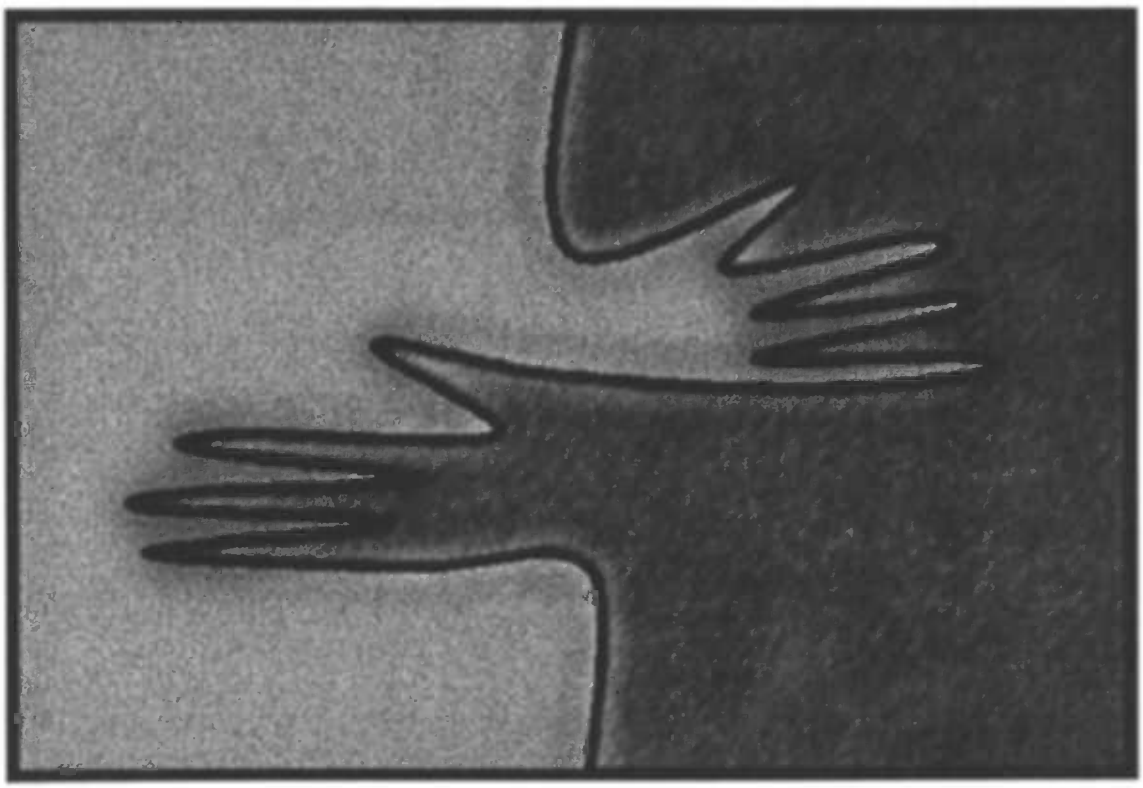
J.F. Scheepens



Biologisch Centrum
RuG

RECONNECTING NATURE AND MAN

A proposal for a different approach in the human use of nature



J.F. Scheepens

Supervisors: Dr. H.J. van der Windt and Prof. emer. Dr. J. van Andel
Rijksuniversiteit Groningen
Haren, december 2004

Contents:

Abstract

A proposal for a different approach in the human use of nature in natural areas, agricultural areas and human-dominated areas, which could be beneficial to both man and nature, is described in this text. Changes include (1) ceasing management in natural areas, thereby creating emerging ecosystems, (2) managing nature in human-dominated areas, thereby reconciliating man and nature, and (3) sustainably using natural resources by sophistically creating new, sustainable socio-ecological systems in agricultural areas. The proposed changes in natural areas and human-dominated areas are based on a replacement of efforts from the former to the latter. In agricultural areas sustainability is the ultimate goal and should be approached by means of scientific research. Different examples of sustainable socio-ecological systems are discussed.

Introduction

Where can we find pristine nature? Nowhere. Not since humans started to dominate the earth and so affected every bit of space on the planet. It is inherent to the definition of *pristine*, meaning *untouched by humanity*, that pristine nature does not exist anymore. In a way, pristine nature can only be thought of today; it cannot be seen. It has become an ideal.
Every organism affects its surroundings including other organisms. A whole web of organisms that depend on each others actions make up an ecosystem which is normally in dynamic equilibrium. Problems could arise when a dynamic equilibrium between man and other organisms in the ecosystem (as with all other organisms and the ecosystem they inhabit) gets out of balance, threatening the integrity of ecosystems (i.e. the capability of supporting and maintaining a community of organisms) and thus of the processes and life forms in the ecosystem.
Wherever man goes, it has impact on its surroundings to some extent. Since the industrial revolution, man does not even have to go to someplace physically in order to have an impact, since certain practices (e.g. the forming of greenhouse gasses) influence the whole earth and not the immediate surrounding. We, consciously or unconsciously, influence nature in various ways: we replace forests by cities or agriculture, determine what type of nature can be found at a certain spot, influence environmental conditions like CO_2 concentration in the atmosphere. All nature is touched by humanity, and often in a way that is unfavorable for the ecosystem.

Let us have a look at what we nowadays call nature: national parks, nature reserves, et cetera. Nature in those protected areas is often highly artificial. In many protected areas intensive management is needed to prevent ecosystems from degrading or collapsing. In many countries, the reason to manage an ecosystem is that by law the individual species must to be conserved; they need a certain type of habitat that needs to be created and preserved. Another reason to preserve certain ecosystems is to preserve historical cultural landscapes, with which man has much affection.
Contrasting, outside protected nature in general no effort is taken to preserve or reintroduce some nature. Nature is only nature when it is assigned nature and then it needs management to stay nature. Relatively untouched natural areas are still to be decided upon what it is or will be.
The species that thrive in human-dominated areas are so-called Kulturfolger (culture followers), opposites of Kulturmeider (culture avoiders), but Kulturfolger more and more become Kulturmeider as stressful factors in human-dominated areas increase (Rosenzweig 2003).
On agricultural land, where man and nature are interacting, many farming practices are not sustainable which means that in the long run the practices cannot be continued due to environmental problems like ecosystem degradation, salinization, pollution, climate change, et cetera. A more precise explanation of sustainability will be given later on. Apart from being unsustainable, human influence on the environment is so stressful that few species can make a living in these rural areas.

A different approach to natural areas, agricultural areas and human-dominated areas could be beneficial to both man and nature. In this text a change in approach for all three areas is proposed and explained, whereafter a discussion follows whether these changes can be seen as belonging to a single change in approach or three different ones. In other words, do the three new approaches have the same basis or ideas about how to encompass both humans and other organisms in a way that is favourable to all?

I will first consider the present condition of nature in protected areas and in human-dominated areas. Then I will introduce the proposed changes in short. After subsequently having explained the use of the term sustainability in this text, I will introduce the concepts of emerging ecosystems and reconciliation ecology as opportunities that nature can be given in natural and urban areas respectively. Furthermore I will explain the concept of socio-ecological systems and how this can be connected to sustainability science. I will discuss some possible theoretical and practical issues and problems associated with sustainable socio-ecological systems. Finally, I will give different examples of action undertaken towards new, sustainable socio-ecological systems.

Nature's domain

Nature's domain consists of national parks, nature reserves or otherwise protected natural areas and relatively untouched nature, like parts of rainforests, coral reefs, and tundra in the northern hemisphere. The protected areas result from human action, so apparantly we have reasons to set aside these areas. What are these reasons, from what values do they arise and what will be the effect of these practices? A historical overview (Van Dyke 2003):

With the establishment of Yellowstone national park in 1870, the first national park in history, J.C. Hedges, one of the founders, used an aesthetic and a moral argument, namely that the beauty he saw must be preserved the way it is in perpetuity and must be accessible to all. The goal was 'object protection'. Hedges knew that without protection others would exploit the area commercially, destroying its beauty forever.

In those days, writers like Emerson and Thoreau were quoted who proposed a spiritual reason to preserve nature based on the romantic-transcendentalist ethic, which argued that the best use of nature was 'not the extraction of its resources as commodities, but the appreciation of its intrinsic values and aesthetic qualities through which the human spirit was renewed and reformed' (Van Dyke 2003). John Muir, a leading American conservationist, made the romantic-transcendentalist ethic the basis of the nature preservation but also understood that public support, political will and permanent legislation are necessary components of success.

Morality, aesthetics and the romantic-transcendentalist ethic are reflected in the National Park Service Act from 1916 which states that the goal is to conserve the scenery and the natural and historical objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations. The wilderness myth was born. The institution of a hands-off policy was enough to retain this wilderness. In 1964 the notion of wilderness was formalized in the first Wilderness Act which prohibited nearly all mechanized use and development of wilderness.

Contrary to expectations based on these acts, it seems to have always been an American's right to durably use natural resources that a certain protected natural area provided, which means for example restricted fishing and tree logging to safeguard the existence of fish and tree species populations. Apparantly, durable use does not alter the state of wilderness in their perception. The native indians also survived there for millennia without affecting the wilderness, at least according to the settlers.

Meantime in the 1960s, scientists began to understand that management was necessary in order to preserve native species. For example, in several places where sequoia (*Sequoiadendron giganteum*) is protected, absence of fire suppressed its reproduction and enhanced the succession of white fir (*Abies concolor*). The moral question raised whether free play of fire caused by lightning or even fire management, to save the original state, was wished, since this meant that one cannot longer talk about wilderness. However, further research showed that the abundance of ring scars in sequoia's could not be explained by natural ignitions, thus aboriginal burning should have taken place in the past: what the scientists thought to be wilderness in fact was not wilderness, at least not in the sense of pristine nature since it was touched by humans! There has been a major influence by man.

Speaking of wilderness, most park visitors are little familiar with nature, do not recognize changes in biodiversity and species abundance and would like to experience a 'wilderness' which provides solitude and a counterpart to technological society with as few human traces as possible. The aesthetic or perhaps spiritual experience is what counts, or just an escape from industrial urban life. And since only an expert's eye would recognize management actions taken, managers did not need to bother about the visitors perception and changed their attitude towards nature. Nature is different from urban life anyway.

Thus, the central goal of national park management changed. Its aim shifted towards perpetuation of native ecosystem elements and processes which means preserving all native species, seeking free play of fire, water, wind, predation, and decomposition, fending off alien organisms and permitting the ecosystems to sort itself out. This is a much more mechanistic view on nature in comparison to the former idea about nature. The mechanistic approach used nowadays to manage protected natural areas is scientifically based and is able to achieve predetermined goals.

Nowadays, the idea about pristine, untouched, nature is quite sober. McKibben states in *The end of nature* (1989) that nature no longer exists, since all ecosystems reflect human influence. Even so-called 'wilderness' is affected by humans indirectly, for example via abandonment of aboriginal burning to which certain ecosystems had adapted or effects of elevated CO_2 levels. This, in a way, approves management in all its ways, if neither presence nor absence of management will recreate 'real' nature.

A human effect on nature is one thing, but massive degradation of nature in various ways is another. The need to take measures became more and more clear with the accumulation of data on species extinctions. E.O. Wilson once wrote (1984): 'The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us.' This clear message brought the topic of conservation on the governmental agenda. Following international conferences in Rio de Janeiro and Johannesburg in 1992 and 2002 respectively, maintaining biodiversity was recognized as

of major importance to the world and soon species gained a legal right of existence in most countries. Thus we started to preserve the basis of nature, the species themselves, and, to some extent, forgot about ecosystem processes, at least in the political arena. Preserving species and genetic diversity was found to be most important, because once lost a species will never come back within a timeframe reasonable for mankind. After each big extinction event that happened in the prehistory of earth, it took evolution on average 10 million years to restore the loss. So let us preserve species until circumstances for them get better.
Apart from species, man also values its own rural history and is restoring historical cultural landscapes. Coincidentally, there are relatively many species in lightly human-influenced rural areas (see intermediate disturbance hypothesis, p.12) as were present in former agricultural lands, and a high biodiversity is another reason to conserve historical cultural landscapes. Restoration of degraded (modern-agricultural) ecosystems back to functioning ecosystems is practiced a lot.
In restoration ecology, it is advised to select a reference ecosystem for evaluation of restoration efforts. However, no matter what is chosen as a reference, it is impossible to perfectly restore to the reference state. Perhaps restoring historically existing ecosystems is easier, since the human practices, which could be the driving forces of the ecosystem, are still known. But even then, the typical circumstances from that time have changed and perfect restoration is impossible. In all restoration projects the moving target syndrome will hamper the progress (Van Andel & Aronson 2004). Whenever it is tried to create a certain type of ecosystem, that ecosystem is outdated. Besides, why should restoration to historically existing cultural ecosystems be practiced, since in the course of time, this ecosystem no longer functions in the current society? The consequence is that in order to keep the ecosystem functioning, restoration to historical cultural landscapes is often followed by intensive management. By and large, these historical cultural landscapes are regarded as nature and protected and managed like that, although it is just agricultural land fallen into disuse.

Man's domain

In fact man's present domain can be the whole earth. Defining man's domain as space influenced by man, no single spot on earth will be left. As explained earlier, man has affected every part of the earth since for example atmospheric CO_2 concentrations are increasing due to our activities. However, I tried to make a distinction here between nature's and man's domain: the former being those parts of the earth that undergo minor and only indirect human-induced effects and including places where nature has protected status; the latter being those places which are not protected and where man has major, direct influence on its environment.
Disturbance is the concept that constantly recurs when discussing human influence on ecosystems. Regarding (human) disturbance, one can think of injuring and removing living organisms, creating bare land or increasing light intensity by plant removal. The effects of different forms of pollution and organismal stress can also be categorised under disturbance. In human-dominated areas, disturbance is by definition almost omnipresent and often continuous, shaping the ecosystem to a large extent.
A general pattern in human disturbance can be recognized. Man's domain can be roughly divided into three types of environments: urban core areas, suburban areas and rural areas.

It represents physical gradients from high to lower human population and construction density, pollution and temperatures or from little to more habitat for native species. In other words, disturbance decreases from urban centers outwards to rural areas. All these factors act as filters that sieve only certain stress-tolerant species (McKinney 2002).
These three environments - urban core areas, suburban areas and rural areas - are inhabited by different types of organisms: urban exploiters are those species that live in urban core areas, are very or totally dependent on human resources and are often not native to a region; urban adapters are those species that thrive in half-open landscapes, are adapted to intermediate disturbance regimes and are native to the region and especially the surrounding natural habitats; urban avoiders are those species that are very sensitive to human presence and habitat disturbances (McKinney 2002).
Along the rural-urban gradient, ecosystems emerged that are stable. There is no management at all, except for some friendly citizens providing food for birds in winter. However, if we compare urban nature, for example, with wilderness, if that exists, we can conclude that urban nature is simple in structure; we cannot speak of a complex web of species interactions. If we value an ecosystem higher when it has a high biodiversity and a complex food-web and a high resilience, then urban nature comes out very poor. That biodiversity is sometimes higher than expected in urban areas can be explained by the dynamic heterogeneity in urban areas. However this does not result in a certain extent of complexity in urban ecosystems, because it are mainly generalists that thrive in urban areas. But even generalists have hard times to survive here, since they often inhabit only small areaa that are subject to unpredictable human-induced changes. Most disturbance is severe and without any notion of the urban nature.
Sadly, in most human-dominated areas, the status of nature is impoverishing. Less and less species are able to live somewhere in the rural-urban gradient. Turning to rural areas, especially the green revolution, which introduced new crop cultivars, irrigation, artificial fertilizer, pesticides, monoculture and mechanization, reduced the naturalness of agricultural lands immensely. But also in urban areas, new construction methods are designed with the aim to keep off birds and bats for example, thereby degrading urban ecosystems.
The technological advancement in coffee plantations provides a clear example of the ongoing green revolution and its negative impact on nature in human-dominated areas. Since the introduction of coffee in America in 1726, it was cultivated in the shade of tropical forests. The trees not only generate shade but provide bananas, citrus, guava and firewood or timber as well. The heterogeneity of the plantation is high due to a high biodiversity and differences in tree density and height which creates opportunities for the grower to grow a range of different crops in addition to coffee. Although not all tropical species can live on a coffee plantation, most can. 60 to 70 percent of the original tropical forest diversity is preserved here (Rosenzweig 2003).
But things started to change when, in 1970, a harmful fungal parasite of coffee, called *Hemileia vastatrix*, started to invade the American plantations after it had already caused India and Sri Lanka to cease coffee growing. The U.S. Agency for International Development (USAID) suggested to grow a variety of coffee that thrived well in hot sun, because the heat would stop the fungus growing and spreading. In addition they suggested the complete list of modern methods already in use in the developed countries, including the use of pesticides, fertilizer and heavy machinery. Although the impact of

the fungus in he Amricas turned out to be not as bad in traditional plantations as in India and Sri Lanka, the advertisement from USAID made more than 40 percent of the acres being converted to modern plantations. Obviously, the modern method wiped out almost all diversity since trees were cut and a monocultural approach was implemented. 5 percent of the native biodiversity is able to live on these modern plantations (Rosenzweig 2003).

A mirror world: a proposal

There are many views on what nature is and how nature should be preserved in our increasingly human-dominated world. Views have evolved over time, have sometimes been overtaken by new scientific insights and have sometimes been reintroduced; at present we have a hodgepodge of different ideas about nature and nature conservation brought into practice. It is clear that we live in the postmodern age.
But let me sketch the coarse lines of present nature conservation. The general idea is that nature needs to be managed to preserve species and protected against human influence that threaten the integrity of the ecosystem, as I said before. Opposite, in urban areas in general no management at all takes place and that is more or less the situation on agricultural lands as well. This results in certain amounts and types of nature in the different areas. I think that we can reach more with the same or even less effort. I think that my proposal will benefit both nature and mankind more than the current situation can. Intensive management in protected natural areas, that costs so much effort, energy and money, should be shifted towards urban areas, where nature is in a poor state. At the same time, shift urban measures towards natural protected areas, that means ceasing all (or most) management activities. On agricultural lands, where man is dependent on nature's gifts, a synthesis between both is the goal, with which I mean that man should strive to make use of natural resources in a durable manner. Figure 1. illustrates these ideas, making use of terminology that will be explained in detail later on in the text. From these proposed changes in the way we treat our nature, I think both man and nature can benefit even more than from the practices we perform today.

To be more clear about the proposed changes, I think that ceasing intensive management in natural areas, managing human-dominated areas to maintain more nature, and especially creating a durable agriculture would be better for the earth as a whole than the present situation. I also think that that is possible and that many activities (or inactivities) promoting nature are beneficial for man as well. Let us deepen out these idea(l)s.

I plea for (1) natural (less artificial) ecosystems and thereby introducing the novel concept of emerging ecosystems, and for (2) nature management in human-dominated areas introducing the concept of reconciliation ecology. This, in a way, asks for the opposite of the current situation, where we intensively manage nature in protected areas and let nature in cities sort herself out. In addition (3) I argue for a sustainable use of natural resources by sophistically creating new, sustainable socio-ecological systems. These new socio-ecological systems can categorically be placed in between natural protected areas and urban areas and represent functional human activities that benefit

nature too. The creation of interdepence between nature and man in agricultural areas is not risky but benefits both parties.

Sustainability

Before starting the discussion about the proposed changes in practices towards nature, I would like to explain the term sustainability because it is such an important term in this text. In addition, the term sustainability is a multi-explicable term, so it is wishable to give a definition of the way I use it. Talking about sustainability, I always mean the sustainable human use of natural resources. If resources are extracted from a certain ecosystem or if the ecosystem provides services for human benefit and if this happens in a way that can be maintained forever, the use is sustainable. Thus, sustainability is not applicable to ecosystems or its processes per se, but always involves human use or action. For example, burning fuel in a lifeless desert is probably not sustainable, since this is indirectly influencing life on earth in a negative way by raising the atmospheric CO_2 concentration. One should regard the range of impact of the action on all ecosystems and other (sustainable) uses and actions. So an important point to note is that one should always consider all energy uses, production and sources and the range of the effects.

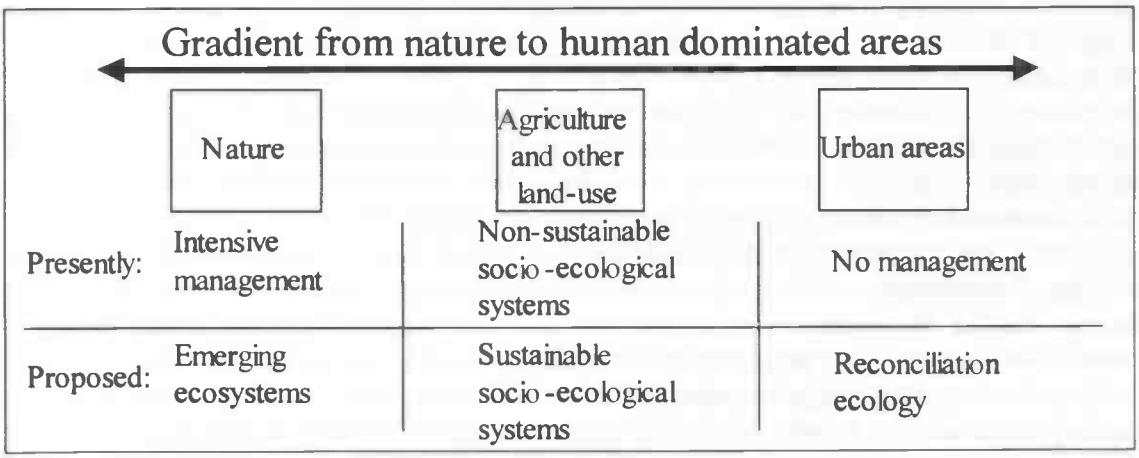


Figure 1. Illustration of the present situation and the proposal regarding nature, agricultural and urban areas.

Therefore, management in nature reserves can be examined on sustainability as well by regarding human energy input and resource removal, but I will go into detail on this later. Interaction between humans and ecosystems is sustainable when a social system (i.e. the regular human actions in a system) and an ecosystem are co-adapted (Marten 2001). The fact that co-adaptation took place, means that both the social system and the ecosystem are in equilibrium and rely on each other to retain this balance. Accordingly, an ecosystem adapted to a certain human disturbance regime can collapse or can be replaced by another ecosystem if humans change the current disturbance regime. An ecosystem that is used by humans can also collapse or be replaced by another ecosystem if humans overexploit the system. It often occurs that due to overexploitation, species disappear from the ecosystem through which an ecosystem degrades to a lower stable state which means that the biodiversity and the complexity of the ecosystem is decreased. Changes that take place on an evolutionary time-scale can be tracked by both humans and ecosystems, but sudden changes in a social system or in an ecosystem can disrupt the co-

adaptation between humans and the ecosystem, which can eventually lead to reduced or ceased ecosystem services (Marten 2001). Human disturbance regimes change much faster than evolution proceeds, thus it is wise to track the effects of changes in disturbance in order to be able to react quickly on negative consequences.
Ecosystem services have been defined by Daily (1997) as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life". Many ecosystem services – providing clean air, erosion protection, carbon sequestration, etc. – have no well-defined owners but benefit all life on earth. The social aspect of sustainability science deals with the question how we can safeguard these services socio-politically, which nowadays are often overexploited. Although a very important aspect in the progress towards sustainability, I wont disuss this social aspect any further. I only want to add that legislation and its implementation is, logically, a very important condition for sustainable use of natural resources.

How sustainable is nature management?
Now that we have deepened out the concept of sustainability, let us consider sustainability in nature management practices. The conservation of ecosystems by intensive management is often not sustainable. Many management practices (e.g. tree-logging) use energy that is unsustainably subtracted from other areas, that is unsustainably used in the ecosystem and that has negative effects outside the ecosystem as well ($[CO_2]$ elevation by fuel combustion). Generally, management uses energy in maintaining the ecosystem: it costs physical energy (fat and fuel) as well as money (via taxes) that is in turn earned by non-sustainable practices outside the ecosystem. Ecosystematically, there is (almost) no energy fixation, since natural carbon fixation and respiration are roughly balanced. Consequently, the net flow of energy use is towards the managed ecosystem, which is not a sustainable practice. A solution lies herein that the energy needed for management to maintain a certain state of the ecosystem can, either directly or indirectly, be produced by the ecosystem itself (or somewhere else if present in the same closed energy system) in a sustainable manner. Another solution is that management can be ceased so that one does not invest energy in the ecosystem and accordingly does not need to receive the invested amount of input to create a closed energy system. Closed energy systems are systems in which all energy that is needed for management is sustainably produced within the system and by the system itself. Accordingly, closed energy systems can also be created for human-dominated areas. A system can be as small or as large in area as is wishable and achievable; an extensive area raises the possibilities for energy flows and consequently the options for products, but the advantage of a small system is that it is easier to track its energy flows and sustainability. Important to keep in mind is that the net energy flow (input vs. output) of a certain process has a maximum above which the integrity of the ecosystem is at risk. This can result in a lower state of biodiversity, complexity and/or functionality. It is thus of major importance to investigate these thresholds in order to be able to create sustainable, closed energy systems (Rees 2003).

The criticism of unsustainability is very well applicable to preserved cultural landscapes. (my favourite topic) Preserving cultural landscapes means a return to old practices and old standards (amount of fertilizer, density of cattle, etc.). This management is therefore

quite intensive and not profitable. How environmentally sustainable is this management? Not very much. Let us take a concrete example: one reason to restore and conserve heathland in The Netherlands is to conserve that type of landscape itself because it is cultural heritage. However, the management is quite energy-demanding and labour-intensive; it involves cutting sods on a periodical basis to lower the amount of nutrients in the soil. Although the landscape stays more or less intact by the conservation measures, we support the ecosystem from all angles to keep it running. The problem is that we are conserving a historical cultural ecosystem that depends on a certain human disturbance regime but which fell into disuse after the green revolution in the 1960s. It does not have the functions anymore that it used to have, namely a grazing area for and manure production by sheep. Besides, evidence is accumulating that heathland was not even sustainably used at all in historical times, but that is another issue. Is there no possibility to create a heath-like ecosystem that has an economic function in society again? If yes, then a win-win situation will occur, since the formerly conserved ecosystem can fulfill a sustainable, even beneficial function, while energy input from outside has decreased, ceased or has been balanced by the output. If the cutted sods can be efficiently used as fertilizer in agriculture or horticulture, we are a step ahead towards a closed functional system, in economic as well as in ecologic terms. This substitute for the heath system contains comparable species and processes but its resources are used in a different way in the new, closed energy system. It does not matter whether the system is extensive or small, as long as all energy and resources are provided by the system itself, directly or indirectly, in a sustainable way and all waste can be assimilated by the system sustainably. I share the comprehension that it is important to save cultural history as humanity progresses, but that does not mean we should conserve non-sustainable ecosystems. Nature is dynamic and evolving and human resource demands change over time. We need to find new ways of interaction between nature and man that are sustainable as well as dynamic (i.e. able to evolve).
Contrary to saving historical cultural landscapes, conserving species is a different issue. Species are mostly conserved as a short-term solution for the problem of species extinction. It also costs a lot of energy to achieve this, is therefore not sustainable, but we often have no other choice available if we want to save them from extinction. And eventually, we will benefit from the conservation actions when the saved species are able to thrive on their own again. A requirement is that existing natural ecosystems are protected and that new natural ecosystems are restored.

Emerging Ecosystems

As has been said, the wilderness concept was replaced by a more mechanistic view on nature in the 1960s, which proved to be better able to preserve species and genetic diversity due to its scientific, analytic basis which allowed predictions. In order to achieve this, the managed ecosystems often have to be supported intensively in order to prevent degradation. However, relatively new insights revealed that degradation is not always the right term to use; we often deal with a change of species assemblages and abundances. Ecosystem compositions change with evolutionary change of ecosystem components, but even faster by changes in human disturbance regimes and human-altered environmental conditions. Succession perpetually follows different routes towards different climax states. And so the idea of wilderness recently regained support as it

favours ecosystem processes to act independently. Such a wilderness can be called an emerging ecosystem (EE).
I will apply the concept of EEs predominantly in the discussion on natural protected areas although it is also applicable to human-dominated areas. Nature is present everywhere along the gradient from protected nature towards urban core areas, but I drew a line between nature's domain and man's domain for clarity's sake, the former being not or only indirectly influenced by man, the latter being directly influenced by man. For the latter I will use the concept of socio-ecological systems explained in a different part of this text. Other than this distinction may imply, natural protected areas do more than preserving species and processes; they have important functions for man. They provide many valuable ecosystem services like sewage water filtration and carbon sequestration. We therefore have influence on these ecosystems indirectly or even directly. So please keep this in mind when I discuss the use of natural protected areas.
The main idea is that emerging ecosystems might be an alternative for intensively managed natural areas. Emerging ecosystems have been defined as nature's response to the new disturbance regimes caused by humans (EE forum on www.unesco.org/mab), but this definition needs some explanation. In other words, an emerging ecosystem is an ecosystem whose species composition and relative abundance have not previously occurred within a given biome. Naturally, ecosystems evolve by evolutionary and natural environmental change over time, but human influence accelerates the rate of environmental change. Therefore new ecosystems will emerge at a much faster rate than in absence of human influence. Defining a natural ecosystem as a system with stable dynamics and without influence of man, an EE sometimes emerges after intensive human use and subsequent abandonment of a certain area (which often happens after overexploitation), but an EE can also emerge by a change in the continuous human disturbance regime, brought about by changes in social, economic and/or cultural conditions. Concrete causes for the rise of an EE can be human-induced extinction or change in relative abundance of original species and/or introduction of alien species; human-influenced landscapes surrounding the EE functioning as dispersal barriers; direct and indirect human impact changing the abiotic environment. Thus, every change in human influence on an ecosystem can change this ecosystem to a new, dynamic ecosystem composition and can subsequently be called an EE. This paragraph summarizes the concept of EEs as proposed after two workshops on the topic (Granada, Spain in October 2002 & Brasilia, Brazil in May 2003).
The notion of emerging ecosystems as being in a stable state or in dynamic equilibrium is very important. It is a prerequisite for an emerging ecosystem to be in dynamic equilibrium, whether in absence, in spite of, or thanks to continuous human influence. An imbalanced ecosystem cannot be called an emerging ecosystem, since it is unknown in what state it will eventually stabilize. Stating this, it seems that certain properties are attributed a priori to natural ecosystems. Some expectations of how nature should be, are built-in in the definition of emerging ecosystems. Apparently, an emerging ecosystem should be in dynamic equilibrium and, if influenced by man, should continually stay influenced in the same manner. Another adding is that the emerging ecosystem must have something to offer in terms of ecosystem functioning; it must have a certain standard comparable to other 'native' ecosystems. An acre of infertile soil after deforestation cannot be called an emerging ecosystem. There must be some processes going on, some

energy flows between different functional groups of species. In cases where the stable state is a dead one, the simplest restoration efforts that create the initial conditions needed for a new ecosystem to emerge are most welcome. These often speed up the initializing process that otherwise would take centuries to happen.

Although the concept of EE is applicable to nature in protected areas, it is also applicable to nature in human-dominated areas, such as agricultural land and urban areas. This should be kept in mind, although the concept is deepened out with the focus on protected areas. The core idea is to accept EEs as natural and to oppose the idea that restoration to a former ecosystem is needed to regain natural ecosystems. There are no values associated to EEs beforehand, but a value can be expressed afterwards in, for example, economic terms (e.g. management vs. no management). Focussing on protected nature, an EE can have a lower biodiversity than its predecessor, but the value of the EE lies therein that it is likely to be more resilient (able to withstand disturbance) than a former managed ecosystem because its dynamics are independent from human actions and have been adapted to the new biotic and abiotic circumstances. Therefore, an EE might benefit humans and other species more than when an ecosystem is brought back to a former state artificially, but can also have negative consequences in biodiversity or economic terms.

As said before, in many cases ecosystems have been destroyed and have reached a stable state without any organismic activity and emerging is impossible. This state was reached because the ecosystems have not been used in a sustainable manner. EEs should be promoted if occuring, but we cannot count on them as the solution for destroyed ecosystems. Although ecological restoration can help ecosystems to emerge out of the dead stable state, the fact that it is impossible to restore an (emerging) ecosystem to its exact former state, argues for conservation of less impacted ecosystems if this does not need intensive management.

Important to note is that although I argue for ceasing management in natural protected areas by using the EE concept, protection of nature in legislative ways and via international protocols is definitely needed. Protection of the natural processes must be secured and law concerning recreation must be clear to visitors. I imagine that particular ecosystem services can be exploited in particular natural protected areas, creating a range from ecosystems without any direct human use to ecosystems whose services are used to the extent that sustainability and integrity of the ecosystem is guaranteed.

Recently, Puerto Rico's new forests have been mentioned as EEs (Lugo & Helmer 2003). These forests emerge on abandoned agricultural lands. The species compositions in these forests are new to Puerto Rico, which includes dominant alien tree species. Probably, the alien tree species facilitate regeneration of native tree species. The new forests function as refugia for native species which have to deal with a rapid turnover of forest into agricultural lands. After 60 to 80 years, the new forests have a species richness and structural features identical to native forests of equal age (Lugo & Helmer 2003).

Another example of an EE is New Zealand's rain-shadow tussock grasslands. After the first settlement on New Zealand by Polynesians in 1200-1300 AD, the extensive forests were burnt and tussock grassland and shrubland communities prevailed due to ongoing fire management. From 1850 onwards, European settlers brought pastoralism with more frequent fire and intensive grazing predominantly by sheep. This leaded to a shift from tall to short tussock species. In recent times, alien herbaceous and woody species start to dominate the islands where grazing is diminished (Hobbs *et al.* in review).

The tussock grasslands are an example of an EE since they have been induced by human activities. This is not a case of aressted succession by grazing, because the grasslands cannot be brought back to the pre-settlement forest ecosystems due to the presence of the woody alien species waiting for a chance. And since the present grasslands are desirable in ecological respect and are sustainably used, there is no need to cease current human activities (as some conservationists wish) since this safeguards the present condition of the EE (Hobbs *et al.* in review).

Reconciliation ecology

We now focus on human-dominated areas, which encompass the range from rural landscapes to urban areas. We have already described what nature depicts in these areas and what the progress in nature is. Rosenzweig proposed a new branch of ecology: reconciliation ecology, 'the science of inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, or play' (Rosenzweig 2003). Reconciliation can be focused both on particular species or on biodiversity in general.

Rosenzweig uses the term *companion places* (Rosenzweig 2003) to indicate human-dominated areas which have been made appropriate for at least one native species to live in. The USNWF Backyard Wildlife Habitat campaign, which encourages home-owners to attract native species to their backyards, is a step in this direction, but several improvements can be made according to Rosenzweig: specific habitats for well-identified species are needed, also covering endangered and threatened species; habitats must be able to carry self-sustaining populations of species (Rosenzweig 2003).

Reconciliation ecology is pre-eminently the practice that makes Kulturfolger out of Kulturmeider. It involves research, is mostly species-based and eventually needs active citizens to realize reconciliation. It does not cost a lot of money, only needs attention and goodwill and is therefore not unsustainable but cheap conservation. If the habitat characteristics of a certain Kulturmeider are known, the habitat can be artificially created in human-dominated areas. By doing so, we can lower the amount of Kulturmeider and therefore relieve pressure on managed nature to preserve Kulturmeider species. Of course there will always be an amount of species that are just not able to live among humans per se and these still need to be preserved in protected natural areas as a temporal solution.

Here an example: reconciliation with the eastern bluebird, a Kulturfolger. After people noticed a steep and stable decline in eastern bluebird populations in the US in 1958, it was said that the absence of holes in dead and dying trees was the main reason for decline. In addition, the few artificial nest boxes present were occupied by nonnative house sparrows and starlings. Hope rose when it was discovered that boxes with holes of 3.2 cm suite bluebirds and exclude starlings and shallow (10-13 cm) boxes are disliked by house sparrows. The use of the adjusted nest boxes made the eastern bluebird population rise again.

Other examples of reconciliated nature include parks that have been created artificially by urban govenrments. Wildlife is often attreacted to these areas. In Golden Gate Park in San Fransisco, California, gives a natural appearance although completely artificial. In the 410-hectare area, ponds, meadows, trees, everything has been dugged, mowed and planted. 11 species of exotic waterfowl have been introduced, but 111 native bird species

have made their homes in the park. Nowadays, researchers are trying to make the park attractive to even more species (Rosenzweig 2003).

SES - Socio-Ecological System

Up till now, reconnecting man and nature is not quite what was propagated: we ended up with left-alone nature as emerging ecosystems and with highly managed (and therefore human-dependent) nature in human-dominated (mainly urban) areas; both for the sake of nature. Here, the reconnection with nature is not in the functional, but only in the moral, recreational and even spiritual sense. However, there is also a functional reconnection possible if not necessary. I already discussed this a little bit in the section about EEs and the services that natural protected areas provide us, but let us deepen out this connection between man and nature. Man is dependent on natural processes that produce food, construction materials and energy. A full reconnection with nature in this sense means creating a system in which nature and man are in balance, meaning that within the ecosystem humans and other species durably take part in the system, and that their activities have been adjusted to each other. As said, the most obvious space where man and nature are necessarily combined and where reconnection in this sense is perhaps possible, involves agricultural land, natural resource subtracting industry and services providing ecosystems. This could even be the space where most reconnecting between man and nature can be achieved.

The systems in which man and nature are associated - either sustainably or unsustainably - are called socio-ecological systems. EEs can also be socio-ecological systems if sustainably used. Socio-ecological systems are co-evolving systems that include interdependent social and ecological subsystems. An example is a historical heathland which originated through the interaction of man and nature. It seems a fair balance between ecology and human activity, regarding for example their interdependence, biodiversity indices and economic aspects of this system; it throve for centuries. Another example is the extensive monoculture of a soya-farmer. The socio-economical system imposes the farmer's modern practices involving the use of pesticides and fertilizer. The ecological aspect is poor, because all life is controlled: pesticides kill everything alive except for the soya. By this, modern monocultural cropping provides opportunities for new diseases to evolve quickly, because many niches are unoccupied and can be filled with organisms resistant to pesticides and specialized in affecting the only present crop which harbours low genetic diversity (Swift *et al.* 2004). Organic methods, on the other hand, cause most niches to be occupied by neutral or even advantageous organisms, giving less chances to diseases to evolve. I do not want to go into technical detail too much, but only mentioned this example as one of the long-term drawbacks of monocultural cropping that makes it unsustainable; there are many. Anyway, one can hardly speak of a socio-ecological system because of the absence of the ecological part, but regarding socio-economics, this is the farmers only method to make profit; it works, at least short-term. In both examples of socio-ecological systems, it is necessary to question the status of sustainability, which especially regards long-term effects of practices. We enter a future in which we must weigh every action and its (long-tem) consequences, including energy and capital flows and ecologic and economic stability. (http://www.anthro.univie.ac.at/humecol/research/socecsys.html)

The Amsterdamse Waterleidingduinen (Amsterdam Waterworks Dunes) are a good example of a soco-ecological system. This highly managed dune ecosystem provides clean drinking water for the citizens of Amsterdam by subtracting filtered groundwater. In addition, it functions as a natural and dynamic barrier against the sea, it serves as a recreational area and it harbours a high biodiversity. The 3400 hectares comprise a healthy, dynamic ecosystem which safeguards the water filtering service of the dune ecosystem. The current management is aimed at sustainability, meaning for example more grazing and less mowing to keep the vegetation low. When the demand for drinking water raised in the 1950s, pre-treated water from the Rhine river is pumped onto the dunes where it subsides into the soil, within the limits of sustainability. Nowadays, 94 million cubic meters drinking water is produced annually by this natural industrial area. The economic and ecologic advantages of this socio-ecological system are very valuable. The ecosystem provides all functions otherwise executed by water treatment installations that are expensive and use much energy and many chemicals to clean the water (www.wlb.amsterdam.nl).

Biodiversity, resilience, disturbance and productivity

It is interesting to investigate how the concepts of biodiversity, resilience, disturbance and productivity are connected to each other, because it involves human as well as natural factors. It might therefore be important in questions about sustainability. Many scientists ventured to find relationships between these concepts (May 1973; Huston 1994; Loreau 2000). Suppose that if an intermediate human disturbance creates a high biodiversity in a certain ecosystem, following the intermediate disturbance hypothesis, then this high biodiversity might create a high ecosystem resilience, meaning that it is able to restore itself to its former state easily. A high biodiversity and resilience in turn might have positive effects on the ecosystem's productivity. Socio-ecological systems with these abilities are optimally advantageous for nature as well as for humans. For sure, the relationship is probably not that simple and will depend on the ecosystem, environmental conditions and species interactions. But when designing sustainable socio-ecological systems, it is important to remind that the following can be a possible situation in an ecosystem: sustainable use is guaranteed by resilience, is guaranteed by biodiversity, is guaranteed by disturbance, is guaranteed by sustainable use, et cetera. It is a circle in which man has an important role in maintaining the sustainable use for its own benefit and for that of the species. The concepts of resilience, biodiversity, disturbance and productivity will be discussed in more detail for their importance in socio-ecological systems.

Disturbance can be defined as "a change in conditions which interferes with the normal functioning of a given biological system" (Van Andel & Van den Bergh 1987), 'normal' being 'without direct or indirect human influence'. When regarding an ecosystem and its components, the consequences of a small disturbance are often quickly restored, those of a bigger one might damage an ecosystem forever. When a disturbance is a resource exploitation, the possibility (and rate) of autogenous restoration of the ecosystem to its former state is an important fact to know. Ecologic stability is recognized as one of the most important factors in sustainable use of ecosystems. The technical term for the possibility of autogenous restoration is resilience.

Resilience, a concept first described by Holling (1973), is the amount of disturbance that an ecosystem could withstand without changing self-organizing processes and structures (Holling 1973; Perrings 1998), or in other words before degradation to a lower stable state, which could imply less productivity and/or less biodiversity. Some scientists use the term in this way that a higher resilience means a quicker restoration to the former state after a disturbance took place (Pimm 1984: Perrings 1998). Resilience is thought to be often safeguarded by the interaction of many different species present inside and outside the disturbed ecosystem, and therefore conserving a high biodiversity enables ecosystems to react on changes more easily (Perrings 1998). This at least is true for ecosystems that are subject to impredictable natural disturbances. In relatively undisturbed or regularly disturbed ecosystems, a high biodiversity index indicates a complex web of specialized interactions that therefore might be very sensitive to disturbance (Perrings 1998; May 1972).

The intermediate disturbance hypothesis states that biodiversity in an ecosystem is highest when there is intermediate disturbance (Connell 1978). As said before, human disturbances can be injuring and removing living organisms, creating bare land or increasing light intensity by plant removal. Human disturbance was explained as a human-induced change in conditions which interferes with the normal ecosystem functioning. The notion here is that disturbance is not necessarily a negative term, since certain species and processes can be favoured by certain disturbances, meaning that certain species will have higher fitness due to the disturbance, which in turn have their effects on certain ecosystem processes. The explanation is as follows. There is a certain amount of species that can live in a certain area somewhere along the successional gradient; some are pioneer species, some are climax stage species, some live somewhere in between, others are able to live in the area all the time, for example. Suppose that disturbance creates patches where succession is brought back to the pioneer stage. Under a high disturbance regime, the area that is in the climax stage decreases faster than succession can catch up with and from a certain moment on there is no progress beyond pioneer stage, so all end-stage species will disappear. Under a low disturbance regime, pioneer species are not abundant enough to be dispersed quickly to newly disturbed patches and will disappear from the ecosystem by competitive exclusion. Concluding, there is an intermediate amount of disturbance that maximizes biodiversity, because all stages of succession are present in such a proportion that all species possibly able to live in the area are maintained in viable populations (Connell 1978). This is the theory and most tests result are in favour of it (Sousa 1979a; Sousa 1979b; Valiela 1995; Lubchenco 1978), but there are contrasting results and a lot of discussion is going on about the intermediate disturbance hypothesis as a general applicable theory. Aside from contrasting results, one of the problems is that disturbance itself is hard to measure (Van Andel &Van den Bergh 1987). Often, the effect of disturbance is measured, relating it back to disturbance. But another problem is how to measure the amount of disturbance itself. For example, heavy disturbance only once in four years can be rated as high as a light disturbance every year, but the effects can be different. Concluding, the intermediate disturbance hypothesis is something to reckon with. It can be valuable for nature and man in socio-ecological systems, where disturbance is necessarily present.

Arriving at the relationship between biodiversity and productivity, theory predicted a correlation between these concepts (Loreau 2000; Worm & Duffy 2003) which studies

have proven to exist (e.g. Chase & Leibold 2002; Rosenzweig & Abramsky 1993; Tilman *et al.* 2001). However, the direction of causality between biodiversity and productivity is not agreed upon (Worm & Duffy 2003) as well as the mechanisms by which the one influences the other. Much research is to be done in this interesting field of ecology as it might allow successful ecosystem engineering in the future, making optimal use of ecosystem processes.

Creating sustainable socio-ecological systems

I described emerging ecosystems as more natural than managed nature and stated that reconciliation with nature should take place in urban areas in the form of intensive management for the protection of species. In between lies the socio-ecological system, where nature is given a chance in human-dominated areas. What will be the outcome if we try to create these kind of systems? Can it be beneficial for both parties, or is it always detrimental to ecosystems compared to natural ecosystems? Can sustainably used socio-ecological systems actually exist at all?
A lot of experimenting is going on all over the world to create sustainable socio-ecological systems. Some attempts are described here serving as examples of different ways to achieve a sustainable socio-ecological system. They comprise different levels of interaction between social and ecological systems. What do they have in common and what are the differences?

Permaculture – Goal: sustainable use of agricultural land with high biodiversity and ecosystem complexity.
Permaculture (permanent agriculture) is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems (www.permaculture.org.au). Permaculture asks a smaller-scale agriculture with a focus on design, the missing factor in modern agriculture. It seeks the best relative placement of components which optimizes the balance between resource harvesting, energy creation and conservation and pollution or waste reduction or elimination. Permaculture implements a broad range of plant types filling many niches available in a certain area. Since plants differ in root depth, height and shade tolerance, many different plant species can be grown close to each other, benefitting from their neighbours. In addition, the high plant diversity attracts a broad range of insect species adding functions to the ecosystem and making it more resilient to disturbances. Scientific evidence is accumulating (Tilman *et al.* 2001), but permaculture already made use of the fact that a high biodiversity increases total yield. Furthermore, permaculture is wholly organic in the sense that artificial fertilizer, pesticides and insecticides are not used. It has no premade plan, since in every place on earth, the system should be designed in a slightly different way according to the environmental circumstances and available species.
A successful permaculture project has been set up in the desert of Jordan (www.permaculture.org.au). The aim of the project, directed by Geoff Lawton, was to re-green the desert and to create a sustainable agricultural system. Most important was the construction of a swale, a dyke construction that catches the rainwater - a ditch on contour. The edges of the swale were mulched with organic matter. On its south bank, nitrogen-fixing trees were planted to shade the swale, diminishing wind evaporation, and

to fertilize the ground. Meantime, the roots of the trees are irrigated by the leaking water and the established irrigation system. South of these trees a variety of fruit trees were planted and agriculture could start. Salinity problems were expected, but the low amount of irrigation prevented salt to be washed to lower soil levels which in the end enhances salinization. In addition, the big amount of mulch created an ideal humid micro-environment for detrivorous species which enhance nutrient cycling. In many places all over the world, permaculture has become a practiced method as successful as in Jordan.
The social aspect of permaculture is agriculture; humans are the dominant actor in the system. They determine what grows where. Obviously, the means to achieve yield are the crops, but used in a very sophisticated way as to optimise growth conditions. Every organism is used for three reasons: yield, structure and biotic effects. Yield is simply where man feeds on; with structure one can think of all physical effects that plants have on their surrounding like shading and wind shielding. Biotic effects are effects like hosting other organisms that feed on plague insects.
In permaculture social and ecological aspects go hand in hand; every social choice forwards has direct benefits for the ecosystem in terms of species diversity and/or productivity. In permaculture, social aspects and ecological aspects are not opposed to each other but a benefit for one is a benefit for the other.

NTFP – Non-Timber Forest Products – Goal: sustainably substracting resources from forests.
Research in ecological economics has shown that the sustainable gathering and selling of non-timber forest products (NTFP) from tropical forests is most often economically much more beneficial to the local population than logging (Wilson 1992). Already after 3 years, the net profit of sustainably subtracted and sold NTFPs, including the transport costs, can be higher than that from the cutting and selling of tropical hardwood. The big advantage is that the ecosystem remains mostly intact. Rubber-tappers in Brazil, for example, draw their income from rubber as well as from other wild products within the tropical forest. They are dependent on the forest so are devoted to its preservation. In a way, they have become part of the ecosystem since they disturb it in such a way beneficial for other species (Wilson 1992).
Another example where subtracting and selling NTFPs can outcompete one-time logging is the Peruvian Amazon. A 1-hectare plot of tropical forest was found to contain 275 tree species of which 72 produced products that could be sold on the Peruvian market, like fruits, vegetables, wild chocolate, and latex. The annual net yield of NTFPs per hectare was estimated to be Euro 333,- while oneshot logging yields a onetime Euro 753,- (Peters, Gentry and Mendelsohn 1989).
Although by definition not belonging to the class of NTFPs but worth mentioning is strip-logging, a practice imitating natural treefall in tropical forests. The practice is sustainable, because a small strip of trees is harvested on the contour of a hill with a road above it to transport the trees; the year after a strip above the road is cleared and nutrients plus seeds wash down on the road and the first cutted strip regenerating the forest there. This cycle can go on infinitely (Jordan 1982).
The social aspect of NTFP is humans subtracting resources from the ecosystem. This is done to such an extent that it leaves the ecosystem intact, securing future use. In general, subtraction does not especially have positive effects on the ecosystem, but some (Wilson

1992) say that it actually has positive effects on ecosystems in certain cases due to the intermediate disturbance that subtracting resources generates. However, although social aspects and ecological aspects are balanced as to safeguard future subtracting, an increase in social impact is likely to have negative consequences for ecosystem integrity. Therefore, the situation is fairly different from permaculture.

MAB - Man and the Biosphere program – Goal: scientifically experimenting with sustainable communities.
The UNESCO Man and the biosphere program aims to set up Biosphere Reserves, which are 'living laboratories' for testing the effects of nature management in a social context. Three basic functions should be fulfilled by the reserves, namely (1) conservation of landscapes, ecosystems, species and genetic variation; (2) socio-culturally and economically sustainable development; and (3) logistic support of exchange of information on conservation and development (www.unesco.org/mab).
Biosphere Reserves are divided into core areas, buffer zones and transition areas. The core areas are needed to preserve diversity of all levels. Only monitoring is allowed in the core areas, which are legally protected. In the surrounding buffer zone, activities are aimed at preserving the core area. Mainly research and to a certain extent education and tourism are allowed here. The transition area is the most human-influenced area. Here, sustainable land-use must benefit local people (www.unesco.org/mab).
Currently, there are 459 biosphere reserves in 97 countries all over the world. To highlight one, El Kala, a biosphere reserve in Algeria founded in 1990, counts 76.000 hectares and is bordering the Mediterranean Sea. It is inhabited by 87.000 people and is visited by 30.000 Algerian tourists each year. There is no commercial, international tourism, but ecotourism might be beneficial for the reserve. Public education and awareness programmes help the citizens find smart solutions for the problems of increasing urbanization and water consumption and the extension of agriculture and infrastructure. Furthermore, social, historical and biological research is done in El Kala (www.unesco.org/mab).
The social aspect is distributed over a cline from heavy impact in the transition zone towards zero impact in the core areas. The core area is a reference area, but also functions as a source for species diversity towards the other zones. In the transition zone, the social impact is mainly agriculture which is in constant developmental state to improve the interaction of agriculture and the ecosystem. The similarity between permaculture and MAB projects are that both develop methods that have beneficial effects for man as well as the ecosystem as a whole. The main differences between permaculture and MAB projects is that the latter is not restricted to agriculture, but could also involve, for example, small scale industries and generating electricity in ecologically sound ways. The advantage of MAB projects is that it includes every human need and tries to unite this in a small-scale system, whereas permaculture is restricted to agriculture. However, practices in biosphere reserves will sometimes have beneficial effects to man as well as the ecosystem, like in permaculture, and will sometimes have negative though controlled effects on the ecosystem, like in NTFP subtraction.

Auroville – Goal: a sustainable community.
Auroville is a township in the making situated in south India near the eastcoast. Nowadays it hosts 1800 people from different countries of the world of which one third is Indian. It is seen as an experiment to achieve a higher level of consciousness through human unity in diversity and is supported by the Indian government and UNESCO. Apart from the spiritual notion, Auroville is also very concerned with sustainable living and environmental human needs. Because of the experimental notion, research is very important as an objective method to analyse progresses in various domains.
When Auroville was established in 1968, the soil was infertile and dry, almost without vegetation, eroding by floods during monsoons and by wind during the rest of the year. However, the area used to be a forest 200 years ago, but the need for timber and the fear of tigers made people cut the forest. Why set up a community on this almost barren land? But massive tree planting and water conservation changed the area remarkably. Several check-dams built in gullies have greatly reduced erosion and together store 25.000 m3 water of which a small part infiltrates into the ground with positive effects for nearby vegetation. The tree planting has resulted in new forest ecosystems and has attracted many other species from outside the area. The cool microclimate under the trees made Auroville a liveable place for its citizens.
Auroville has a reasoned spatial planning. The so-called green belt surrounds the inner circle, which is divided in 4 zones: a residential, an industrial, a cultural and an international zone. The residential zone and the international zone is where citizens from India and the rest of the world live, respectively. Small-scale, low-impact industrial practices take place in the industrial zone. Education, sport, recreation and cultural practices are located in the cultural zone. Next to being a safe harbor for nature, the green belt is where sustainable, mostly organic farming is practiced and recreation of the citizens takes place. The development of the area is aimed at improving biodiversity and environmental management. For example, the re-established forests in the east protect Auroville against strong winds from the sea, but it also provides waste water treatment, pollination of agricultural crops and other ecosystem services. Sustainable harvest of timber supplies building material for infinite time. Agriculture has adopted the permaculture strategy or high-tech sustainable practices on some farms, traditional farming on others. It is experimenting with indigenous varieties of crops and with the improvement of biodiversity around agricultural lands.
Auroville has a dynamic view on itself and on the biodiversity in the ecosystems that it harbours. The citizens as well as all other organisms are always evolving, changing in components and changing in abundancies. It is not a closed system, new citizens are as welcome as new species if able to make a living there. Auroville is not pre-designed to be sustainable in land and resource use, but strives to evolve towards a sustainable society by being actively searching for it (www.auroville.org).
In a way, Auroville is similar to MAB projects, but the difference between them is that MAB projects are open air laboratories that try to develop ecologically and economically sustainable communities whereas Auroville values the development of the community and not the end result per se. Auroville regards its present state as being the right state for that moment. Similar to MAB projects, Auroville encompasses social practices that benefit both man and the rest of the ecosystem as well as social practices with a negative influence on ecosystems albeit to such an extent that the integrity of the ecosystem is

safeguarded. Finally, it can be argued that Auroville also is a reconciliation project since it tries to harmonize its citizens with nature. However, this harmonization is achieved directly by building a sustainable socio-ecological structure. Thus the activities themselves bring man and nature together. Outside Auroville, man has to understand first what role nature fulfills in the world, which is a lesson taught by reconciliation. That is the basis already present in Auroville.

To conclude, regarding these different projects aimed at creating an ecologically sustainable system, a rough distinction can be made between projects that benefit both man and nature at the same time and projects that try to minimize the negative impacts of practices. The former is, of course, more advantageous but is impossible to apply in every situation.

Discussion

Any effort taken to diminish negative human impact on ecosystems, to favour ecosystem functioning and to save biodiversity is a noble effort these days. As Wilson made clear in his famous book *The Diversity of Life* (1992), the earth is facing an enormous loss of biodiversity due to human activities. Therefore, it should be noted that the concept of emerging ecosystems alone are not the solution to this world problem. The species based protection of biodiversity must go on for the time being to safeguard the ecologic structure of future ecosystems. Nowadays, nature protection is evolving more and more towards ecosystem protection, which is much more sustainable. EE is, however, an important concept that functions as an eye-opener: nature is dynamic and able to change, and should be treated with that important fact in mind. It will not only help humans preserving nature, but will also turn out to be very beneficial to humanity. However, care should be taken when promoting EEs. For example, an alien species could turn out to benefit a certain ecosystem, making it more resilient to human disturbance since it replaces a lost species. Keeping out this alien species requires intensive management which is not sustainable. But what if this EE becomes a host for the alien species infecting other intact ecosystems nearby and pushing out native species? For sure, such problems will rise. Research should be done to investigate the potential benefits and problems; every situation is unique and requires other measures.
Where accepting EEs often means a relief in management activity, reconciliation ecology means an intensification of effort. Citizens are predominantly expected to put their shoulder to the wheel, but will they? This asks for set-up plans from local governments to succeed, which in turn depends on the local and national politics. Education and awareness seem to be the starting point. There is a chance that the trend towards reconciliation ecology will positively feed back, with a beautiful natural urban landscape as prospect.
Everywhere in the world, sustainable socio-ecological systems are recognized, set up or experimented with. Of all proposed changes, this is the most complicated and hardest to succeed. Important is the awareness that economy needs ecology when prospecting on the far future instead of on the short-term. A sustainable earth is the ultimate goal, but before we reach that complete socio-ecological ecosystem, the earth will have lost many species, ecosystems and their functions. It is a race of awareness against ignorence. As the

Senegalese conservationist Baba Dioum has said, "In the end, we will conserve only what we love, we will love only what we understand, we will understand only what we are taught."

The final question I wish to address is whether the proposed changes in natural areas, human-dominated areas and agricultural areas have the same basis in approach. I stated that the proposed changes are the opposite to the present situation but with more beneficial effects to both man and nature. The change from intensive management to absence of all management in natural areas is, indeed, the opposite approach. The change from absence of management to management of nature in human-dominated areas like cities also is the opposite approach. Both will benefit nature, as I explained. However, making non-sustainable socio-ecological systems sustainable is not necessarily an opposite approach. That is because the means are not determined yet and can range from a 'back-to-basics' approach to applying technologically advanced methods. A common element in all approaches is the scientific investigation in this field. The goal of a sustainable socio-ecological system is very complex since there are many factors involved like ecological, economical and sociological factors. The only possible way to incorporate all information and to be able to analyse it subsequently is a scientific approach. Moreover, since the urgence for sustainable socio-ecological systems is clear, this creates the driving force from societies to investigate the possibilities for sustainable socio-ecological systems scientifically.

When regarding sustainability in natural areas, human-dominated areas and agricultural areas, there is, again, no similar basis in these three approaches. In human-dominated areas, sustainability of the small-scale manual efforts from citizens to achieve reconciliation is not a big issue except if much materials and fossil energy is used in the practices. Besides, the effect of reconciliation activities on the socio-ecological system is always beneficial since reconciliation takes place in human-dominated areas where nature is almost absent nowdays. In natural areas, sustainability is not an issue since there is no human activity in these areas, whereas in socio-ecological systems, sustainability is of utmost importance for the function of the system.

Finally, I would like to discuss the function of biodiversity, resilience, disturbance and productivity in the three areas. The question is raised whether the function is similar or different in these areas. Starting with biodiversity, although the meaning of biodiversity is similar in all areas, its function is different. In human-dominated areas and in natural areas, biodiversity has in the first place an intrinsic value, perhaps also a recreational value and to some extent also a functional value since it might provide integrity of ecosystems and therefore integrity of the world at large. However, in socio-ecological systems, biodiversity is a very important aspect since it is here that its relationship with productivity becomes important. In permaculture, for example, biodiversity means functionality since every species is included in a system for its function in that system.

Resilience can be said to have a similar function in all three areas, but only the importance differs. The function of resilience is the ability to overcome disturbance. In socio-ecologic systems resilience is most important to know, because the systems are subject to disturbance all the time. It would even be beneficial to try to increase the resilience of the system as to increase the yield. In natural ecosystems, however, resilience is just a property of the system and there is no direct need to increase the resilience by ongoing management since this could turn out to be unsustainable. Short-

term management like reintroduction of species could be beneficial to natural areas, since this increases biodiversity and possibly resilience as well, which strengthens the ecosystem. In human-dominated areas, resilience would mean that it can withstand the high disturbance present in urban areas and could lead to a decrease in reconciliation measures. If an artifical, urban ecosystem turns out to have a high resilience, less effort is needed to safeguard all reconciled species. It might be beneficial to find out how to create resilience in urban ecosystems. Which species create resilience when occuring together? Where do we have to create parks and in what size in order to, for example, create a self-sustaining meta-population? Although not of major concern, this is an area where progress can be achieved.

Disturbance is always necessarily present in socio-ecological systems. Dependent on the extent of disturbance, it might be beneficial to the ecosystem based on the intermediate disturbance hypothesis. It might also be neutral in effect when the amount of disturbance can be absorbed by the resilience of the ecosystem. If the disturbance is too much, it will harm the ecosystem. In sustainable socio-ecological systems, the disturbance must be neutral or beneficial; it is one of the most important aspects that is taken into account in questions concerning sustainability. In urban areas, disturbance is unavoidable and there is hardly any limit to it. Of course, in parks cars are prohibited, but the reason for that is that visitors can find some rest, not the birds. Disturbance is the main factor that drove species away in the first place; now careful action must secure species from too much disturbance. In natural areas, disturbance is the lowest and almost all disturbance comes from sources other than humans. Disturbance can therefore be said to be natural and no action is needed to decrease its impact. Disturbance is not an issue in natural areas.

Productivity is not of much interest in human-dominated and natural areas, where it at best might indicate health of a system. If the productivity is zero, the system is dead, but if there is a high flux of energy, the system is healthy in many cases. However, in socio-ecological systems productivity is of major importance since it is an indirect measure of yield. The higher the productivity, the more yield.

Summarizing, the functions of biodiversity, resilience, disturbance and productvity gain more importance the more is dealt with these concepts. In natural areas, where an abandonment of management was approached, ecosystems function without any imfluence of man so productivity has no meaning here. The only concept of importance is biodiversity, since natural areas might function as sources of biodiversity. In urban areas, nature has been almost absent and consequently these concepts have no meaning here. However, when we want to reconcile species, the concepts of disturbance and resilience suddenly become very important. In sustainable socio-ecological systems, biodiversity, resilience, disturbance and productivity are all of major importance. This is the area where man and nature co-occur and thus where productivity and resilience are important, which depend to a certain extent on biodiversity and the amount of disturbance.

Concluding, the proposed changes in natural areas and human-dominated areas can be argued to be based on a replacement of efforts (from natural to human-dominated areas), which subsequently might be beneficial to both man and nature in these areas. In agricultural areas, the goal of sustainable socio-ecological systems is different from the goals in natural and human-dominated areas, since it is here that man and nature necessarily need to be in equilibrium since they work woth each other intensively. It is also in sustainable socio-ecological systems that concepts as biodiversity, resilience,

disturbance and productivity are most important, since here both man and nature are dependent on these factors most. Sustainability is the ticket to the future for both man and nature.

References

Books and articles

Anderson, J.E. (1991) A conceptual framework for evaluating and quantifying naturalness. *Conservation Biology* 5(3), 347-352.

Chase, J.M. and Leibold, M.A. (2002) Spatial scale dictates the productivity-biodiversity relationship. *Nature* **416**, 427-430.

Connell, J.H. (1978) Diversity in tropical rainforests and coral reefs. *Science* **199**, 1302-1310.

Daily, G. E. (1997) *Nature's Services - Societal Dependence on Natural Ecosystems.* Island Press, Washington.

Hobbs, R.J., Arico, S., Aronson, J. *et al.* (in review) Emerging ecosystems: theoretical and management aspects of the new ecological world order *Global Ecology & Biogeography.*

Holling, C.S. (1973) Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* **4**, 1-23.

Huston, M.A. (1994) *Biological Diversity.* Cambridge University Press, Cambridge.

Jordan, C.F. (1982) Amazon Rain Forests. *American Scientist* **70**, 394-401.

Loreau, M. (2000) Biodiversity and ecosystem functioning: recent theoretical advances. *Oikos* **91**, 3–17.

Lubchenco, J. (1978) Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive ability. *American Naturalist* **112**, 23-39.

Lugo, A.E. and Helmer, E. (2003) Emerging forests on abandoned land: Puerto Rico's new forests. *Forest Ecology and Management* **190**, 145-161.

Marten, G.G. (2001) *Human ecology - Basic concepts for sustainable development.* Earthscan Publications, London.

May, R.M. (1972) Will a Large Complex System be Stable. *Nature* **238**, 413-414.

May, R.M. (1973) *Stability and Complexity in Model Ecosystems.* Princeton University Press, Princeton, NJ.

McKibben, B. (1989) *The end of nature.* Anchor Books, New York, NY.

McKinney, M.L. (2002) Urbanization, Biodiversity, and Conservation. *BioScience* 52(10), 883-890.

Perrings, C. (1998) Resilience in the Dynamics of Economy-Environment Systems. *Environmental and Resource Economics* **11**(3-4), 503-520.

Peters, C., Gentry, A. and Mendelsohn, R. (1989) Valuation of an Amazonian Rainforest. *Nature* **339**, 655-656

Pimm, S.L. (1984) The Complexity and Stability of Ecosystems. *Nature* **307**, 321-326.

Rees, W.E. (2003) Economic development and environmental protection: an ecological economics perspective. *Environmental Monitoring and Assessment* **86**, 29–45.

Rosenzweig, M.L. (2003) *Win-Win Ecology - How the Earth's Species Can Survive in the Midst of Human Enterprise.* Oxford University Press, Oxford.

Rosenzweig, M.L. and Abramsky, Z. (1993) How are diversity and productivity related? In: *Species Diversity in Ecological Communities* (eds. R.E. Rickleffs and D. Schluter), pp. 52–65. University of Chicago Press, Chicago

Sousa, W. (1979a) Disturbance in marine intertidal boulder fields: the non-equilibrium maintenance of species diversity. *Ecology* **60**, 1225-1239.

Sousa, W. (1979b) Experimental investigations of disturbance and ecological succession in a rocky intertidal algal community. *Ecological Monographs* **49**, 227-254.

Swift, M.J., Izac, A.-M.N., Van Noordwijk, M. (2004) Biodiversity and ecosystem services in agricultural landscapes – are we asking the right questions? *Agriculture Ecosystems & Environment* **104,** 113-134.

Tilman, D., Reich, P.B., Knops, J. *et al.* (2001) Diversity and Productivity in a Long-Term Grassland Experiment. *Science* **294**, 843-845.

Valiela, I. (1995) *Marine Ecological Processes.* Springer-Verlag, New York.

Van Andel, J. and Aronson, J. (eds.) (submitted) *Restoration Ecology, a European perspective.* Blackwell Science, Oxford, UK.

Van Andel, J. and Van den Bergh, J.P. (1987) Disturbance in Grasslands – Outline of the theme. In: Disturbance in Grasslands (eds. J. van Andel, J.P. Bakker and R.W. Snaydon), pp 3-13. Dr W. Junk Publishers, Dordrecht.

Van Dyke, F. (2003) *Conservation Biology: Foundations, Concepts, Applications.* McGraw-Hill, New York, NY.

Wilson, E.O. (1984) *Biophilia.* Harvard University Press, Harvard.

Wilson, E.O. (1992) *The Diversity of Life.* Harvard University Press, Harvard.

Worm, B. and Duffy, J.E. (2003) Biodiversity, productivity and stability in real food webs. *TRENDS in Ecology and Evolution* **18**(12), 628-632.

Internet sources

All internet sources were available on January 3 2005.

http://www.headwaterstreams.com/idh.html - Quinlan Consulting Intermediate Disturbance Hypothesis

http://www.auroville.org/ - Auroville

http://www.unesco.org/mab/ - UNESCO Man and the Biosphere Project

http://www.anthro.univie.ac.at/humecol/research/socecsys.html - Socio-ecological systems

http://www.wlb.amsterdam.nl/ - Amsterdamse Waterleidingduinen

http://www.permaculture.org.au/article.php?articleid=18 - Permaculture

Front picture by J.F. Scheepens 2004

Acknowledgements

I would like to thank Henny van der Windt for his supervision and trust and Jelte van Andel for his advice.

WETENSCHAP & SAMENLEVING