Beyond mastery?

Nature management during the Anthropocene

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Introduction

This paper examines some recent, strongly interconnected trends in natural resource management with respect to one of the most basic questions of environmental philosophy - that of human domination and exploitation of nature.

One important trend of the past two decades is **the gradual shift from ecological restoration to ecological design** (section 1). Already in 1989, Michael Soulé predicted the emergence of a new ecological discipline to deal with the new, biogeographically complex assemblages that result from deliberate or accidental species introductions: "recombinant ecology" (or "mixoecology"). From 2000 onward, these new biotic assemblages became established as "novel ecosystems" (or "emerging ecosystems"). Novel ecosystems have unknown functional characteristics and may be difficult or impossible to return to a prior condition. More recently, some have gone beyond the idea of managing novel ecosystems and advocate the creation of "designer ecosystems", i.e., synthetic systems consciously invented to achieve ecological, social, and economic goals. The shift to ecological design is unavoidable when the past is no longer an accurate indicator for the future. But the notion of designer ecosystems could also reinforce the "misguided faith in the hegemony and infallibility of the human power to control the natural world", to use Eric Katz' words.

This would, however, contradict another important trend, i.e. **the collapse of the ideal of absolute control over nature** (section 2). Already during the late sixties of the previous century, ecologists like C.S. ('Buzz') Holling realized that the current command-and-control approach that attempts to turn complex, nonlinear systems into predictable, stable and economically efficient systems by replacing natural ecological controls with engineered constructs has become evermore expensive, irrational and finally counterproductive. A frequent result of command and control as applied to natural resource management is reduction of the range of natural variation of systems which goes hand in hand with increased vulnerability to stress and disturbances. What these ecologists advocate is a less dominant approach that avoids this 'pathology of natural resource management'. This approach allows small scale perturbations to operate in order to prevent large scale disturbances. Cases in point are the 'prescribed' use of fire ('fighting fire with fire'), the reintroduction of large predators (and the 'ecology of fear'), and the recent shift in flood control in the Netherlands (from the 'war on water' to a 'dialogue with water'). In these examples control doesn't disappear but only changes form. This new form of control could, with a wink at sociologist Norbert Elias, be called a 'controlled decontrolling of ecological controls'. This formula makes it clear that giving the dynamics of water, fire and predation more room again is not an uncontrolled process, but asks for new, less rigid and more flexible forms of control.

The success of the strategy of 'controlled decontrolling' is depended on the self-regulating and self-organizing capacities of ecosystems, the very existence of which is threatened by large-scale anthropogenic-driven environmental changes. We are less and less able to 'learn from nature' and have to invent, design and engineer ecosystems according to our economic and social needs. This explains the third important trend in recent debates about natural resource management: **the emergence of the concept of ecosystem services** (section 3). There is great and increasing enthusiasm for this concept among scientist and policy-makers because of the seeming win-win solutions for conservation and development. But I will argue that there are reasons to temper this enthusiasm, and stay alert of the hubris behind the concept.

I. From ecological restoration to ecological design

In this section, I will briefly sketch the shift from ecological restoration to ecological design that gradually took place over the past two decades. To bring this shift into focus, I will use a special lens: the invasive species issue. I will start with the view of ecological restoration as the attempt to return nature with great historic fidelity to its original state. In this view, invasive species are considered an absolute evil that should be eradicated or at least controlled as much as possible. I will end with the view that it is possible and sometimes even desirable to create 'designer ecosystems,' synthetic systems consciously invented to achieve ecological, social, and economic goals. In this view, the distinction between native and invasive species has lost much of its relevance; alien species are no longer seen as detrimental. On the contrary, they may well be more helpful in adapting to chancing circumstances and conditions than native species.

The two roads of conservation and science

Invasion biology and restoration ecology are intimately connected. Both emerged at about the same time and developed as 'sister disciplines' during the latter part of the 1980s, and continued to reinforce one another in subsequent years. They developed an increasingly strong synergy, with the objectives of each reinforcing those of the other. As Mark Davis asserts,

> [r]estoration ecology's emphasis on restoring environments with native species affirmed the importance of invasion ecology, and invasion ecology's emphasis on the harm caused by a small proportion of introduced species provided important justification for restoration ecology's preference for native species (Davis 2006, 49).

In his historical review of invasion biology since 1958 (the publication date Charles Elton's invasion classic, *The Ecology of Invasions by Animals and Plants*), Davis distinguishes two different roads within this young discipline. The first path is the *conservation approach* advanced by Elton and strongly influenced by restoration ecology. David describes this approach as a top-down, deductive approach, in which an effort was made to apply general ecological theory and principles to biological invasions in order to help develop control management programmes for specific invasions. The alternative path is the *scientific approach*. This could be considered more of a bottom-up, inductive approach, in which individual invasions are examined in an effort to better inform general ecological theory and understanding of communities and populations.

> The conservation and environmental emphasis in invasion ecology has been motivated by the conviction that ecological knowledge and theory can be used to better understand and predict biological invasions. The alternative approach was motivated by the opposite conviction — that biological colonisations/invasions can be viewed as natural experiments and used to inform more general ecological theory and understanding (ibid., 53).[1]

[1] The second – scientific – road is less well travelled than the other road. During the past decades, invasion biology has become increasingly more allied with the conservation approach, particularly in the United States.

Because restoration ecology can be considered an equal sibling – “at least a close cousin” (ibid., 51) – to invasion biology, both the conservation approach and the scientific approach can also be found within restoration ecology. The two approaches go in different directions. The conservation approach is mainly concerned with historical fidelity or authenticity, whereas the scientific approach focuses on functionality. At the start, both approaches were rather static but have, in due course, developed a more dynamic outlook. If we take this differentiation between static and dynamic versions of both approaches into account, we will obtain the following matrix of perspectives on restoration ecology that reflect different visions of nature and also shape the invasive species issue. In the remainder of this section, I will discuss these perspectives in some detail.

	Static	**Dynamic**
Conservation Approach: Authenticity	**1. Restoration**	**2. Re-creation**
Scientific Approach: Functionality	**3. Reparation**	**4. Recombination**

1. Restoration

From the outset, ecological restoration’s attempt to return degraded ecosystems to their original state has been compared to the restoration of artworks. There have been heated debates among environmental philosophers whether ecological restoration was indeed comparable to art restoration, or rather to art reproduction or even art forgery, as has been argued by Robert Elliot in his seminal 1982 paper, *Faking Nature*. Just as a reproduction or a replicate cannot reproduce the value of an original artwork, restored nature cannot reproduce the value of original nature. “What the environmental engineers are proposing is that we accept a fake or forgery instead of the real thing” (Eliot 2003, 383). A Van Meegeren will always be inferior to a real Vermeer!

In his 1992 paper *The Big Lie: Human Restoration of Nature*, environmental philosopher Eric Katz further argued that whatever is produced in a restored landscape certainly cannot count as having the original value of nature, particularly wild nature, and that restored nature necessarily represents a form of disvalue and domination of nature. “

> Once we dominate nature, once we restore and redesign nature for our own purposes, then we have destroyed nature – we have created an artifactual reality, in a sense, a false reality, which merely provides us the pleasant illusory appearance of the natural environment (Katz 2003, 396).

“No doubt part of the explanation for this difference is that a large number of ecologists are employed by conservation groups and governmental agencies where they work primarily on applied problems” (ibid., 52).

Other environmental philosophers are less harsh in their judgement of restored nature. Andrew Light (2003), for instance, thinks that Eliot's and Katz' criticism is only valid with respect to a particularly malicious kind of restoration – restoration that is used to justify the disturbance or destruction of nature, for instance for the benefit of some industrial activity, with the argument that it is possible nowadays to create a piece of nature with the same value as the original at a later date or at a different place. But, Light insists, this kind of restoration is relatively rare. Most restoration efforts are undertaken to correct a past harm. In these cases, ecological restoration is more akin to art restoration than to art reproduction or art forgery.

2. Re-creation
However, if we shift the focus from the visual to performing arts such as theatre, dance, and music, the restoration metaphor acquires a different meaning. A ballet, symphony, or play is anything but static; it derives its very life from being recreated time and again. Performances typically involve repetition, but at the same time, a perfect reproduction of an earlier performance would not be a performance at all but a copy of one. Variation is as important to successful performances as repetition—performances are at once iterative and creative. Although this shift redirects attention from composition and pattern to performance and process, it still involves 'authenticity' as the most important standard by which ecological restorations should be evaluated. An artistic performance should be true to the original score, script, or scenario; although the players, props, scenery, and costumes constantly change, the performance has to remain *Hamlet* - or, translated into the drama of nature, it has to remain a *tall-grass prairie* or a *freshwater marsh*.

The emergence of the re-creation metaphor marks the switch from a defensive to an offensive strategy; rather than clinging to the protection and conservation of existing nature reserves, the overriding purpose is to create and develop 'new nature.' Two processes play a key role in the new approach to nature development: abiotic dynamics through free play of fire, wind, and water on the one hand, and biotic dynamics through releasing certain species of large herbivores and large carnivores on the other. The grazing styles of various large herbivores - what they eat and how they forage - have a major impact on the development of particular areas. These foraging patterns are shaped by large carnivores: they reflect the need for herbivores to balance demands for food and safety caused by fear of predation (Ripple & Beschta 2004).

The re-creation metaphor allows for a less rigid framing of the exotic species issue than the restoration metaphor, which implies a sharp distinction between native (and desirable) and nonnative (and undesirable) species. After all, the original composition and the specific patterns of flora and fauna are no longer decisive; we should focus rather on the performance of the system and the dynamic (biotic and abiotic) processes of succession, dispersion, migration, predation, grazing, sedimentation, erosion, fire, and so on.

3. Reparation
So far, we have focused on the dominant approach within invasion biology: the *conservation approach.* We will now turn to the *scientific approach*. There is a huge difference in language between the two approaches. The vocabulary of the conservation approach includes terms such as 'alien,' 'exotic,' 'invader,' 'invasion,' and other explicit bellicose or negative terms, whereas the scientific vocabulary has a more value-neutral character, preferring terms such as 'colonizer,' 'introduced,' 'new arrivals,' and 'migration.' This language is typical for the dominant theory used to understand bioinvasion, i.e. island biogeography, which stems from 'New Ecology,' a new approach within the field of conservation biology that can be traced

back to cybernetics, which flourished in the United States in the early post–World War II era in a climate of technocratic optimism.[2]

In a pioneering paper published in 1948, Hutchinson distinguished between two closely related approaches: the 'biogeochemical' and the 'biodemographic.' Viewed from a biogeochemical perspective, the entire biosphere appears as a giant cyclical system of energy, matter, and information that is able to maintain a dynamic equilibrium due to a series of feedback mechanisms. This perspective was elaborated on, in particular, by Hutchinson's student Howard Odum and his brother Eugene, who repeatedly compared the biosphere, inclusive of mankind and society, to a complex clockwork. The metaphor of nature as a clockwork reinforces confidence in our ability to repair damaged ecosystems in the same way we repair "the radio or the family car," as Hutchinson once put it (Kwa 1987).

The biodemographic approach shares the cybernetic principles, but focuses on groups or communities of organisms - the so-called populations. These populations are perceived as systems attempting to maintain their stability under ever-changing conditions by means of feedback mechanisms. This approach was further elaborated on by Robert MacArthur, another of Hutchinson's students. In the 1960s, MacArthur, in collaboration with Edward Wilson, developed the 'island theory' - a theory on the biogeography of islands.[3] This theory predicts the number of species on a given island, using the size of the island and its distance to the mainland as the principal parameters. MacArthur and Wilson also assumed a dynamic equilibrium: although the taxonomic composition on the island is subject to continuous change, the number of species, which is determined by the rates of extinction and colonization, remains constant.

The island theory once more puts invasive species in a different light. It takes no interest in the question of whether components of the ecosystem are identical in a material sense, but only whether they perform the same function within the ecosystem - for example, as producers, consumers, or decomposers (bacteria and fungi) (Keulartz 1998, 149). Whether a species 'belongs' in an environment is not determined by its origin, but by its function. Species are entitled to a green card, so to speak, as long as they do their job.

4. Recombination

The most radical reframing of the exotic species issue comes from Michael Soulé. In his presidential address on alien species in 1989, Soulé claimed that among the many environmental challenges of the coming decades, bioinvasion will be the most revolutionary. The flood of exotic species will homogenize and impoverish the world's ecological communities, a process he refers to as 'cosmopolitanization.' Soulé is convinced that the flood of exotic species cannot be stopped and that we simply have to accept cosmopolitanization.

Soulé argues that the concept of natural versus artificial, already outdated due to the pervasive influence of humans, is further undermined by the universal and irresistible force of bioinvasion. It will therefore become nearly impossible to defend the ecological status quo ante. According to Soulé, "a policy of blanket opposition to exotics will become more

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[2] When he first coined the word "cybernetics" in 1945, Norbert Wiener defined it as "control and communication in the animal and the machine." Wiener brought together two fields of research: on the one hand, he elaborated on the engineering-oriented research into the "servomechanical" nature of control and communication in machines, using the ideas of information flow, noise, feedback, and stability; on the other, he built on what physiologists like Walter Canon had developed under the heading of "homeostasis": a variety of mechanisms in the organism to maintain fixed levels of blood sugar, blood proteins, fat, and calcium, as well as an adequate supply of oxygen, a constant body temperature, and so on.

[3] Their 1967 book, *The Theory of Island Biogeography*, is one of the most frequently cited books in ecology and popular biology.

expensive, more irrational, and finally counterproductive as the trickle becomes a flood" (Soulé 1990, 235).

Although the psychological adaptation to biogeographically recombined communities will be difficult, Soulé believes that shifts in scientific fashion will facilitate the transition "from the traditional view of biogeographic integrity to the postmodern acceptance of cosmopolitanization" (ibid., 234). The first shift is the decline in status of the "niche paradigm." "Niche" is a key concept in biogeography that is based on a holistic view of biological communities as highly integrated by competitive interactions.[4]

The second shift concerns the replacement of this holistic community concept by an individualistic community concept. The individualistic concept was developed as early as 1917 by Henry Allan Gleason, who opposed the organicist views of his countryman Frederic Clements. According to Gleason, an association of plants or animals cannot possibly be likened to an organism. The development of associations cannot be explained or predicted with the help of a limited number of physical laws, but has a nondeterministic (stochastic) and distinctly historic character. Every association is the entirely unique outcome of a combination of migration patterns and environmental factors. Between the different associations there are only fluid transitions, not the fixed, clear-cut boundaries that would justify a comparison with organisms. Among his colleagues Gleason was viewed, in his own words, as a "good man gone wrong," and his arguments were ignored and even "pulverized" (McIntosh 1991, 137; 265). This changed during the last decades of the previous century when the equilibrium paradigm (and the notion of "nature in balance") increasingly had to compete with the non-equilibrium paradigm ("nature in flux") (see section 2).

Soulé suggested that, as a result of the shift to a more dynamic view, a new ecological discipline would develop to deal with the interactions within new, biogeographically complex assemblages that result from deliberate or accidental species introductions. He suggested calling this ecological discipline 'recombinant ecology,' or 'mixoecology.' This field can be defined as "the ecology of communities of plants and animals, the constituent members of which are drawn from a wide range of global biogeographic zones" (Barker 2000; Gilbert 2005).

Although some might feel that Soulé's suggestion was not meant seriously (see e.g. Enerink 1999), the emerging field has slowly begun to be recognized in work in Eastern Europe and, more recently, in the UK (Rotherham 2005; Crifasi 2005). From the turn of the century onward, the notion of 'novel ecosystems' (or 'emerging ecosystems') rapidly gained currency in debates within restoration ecology (Hobbes & Harris 2001; Hobbs et al. 2006; Harris et al. 2006; Lindenmayer et al. 2008; Seastedt et al. 2008; Hobbes et al. 2009). Novel ecosystems may contain new combinations of species that arise, not only through the impact of the deliberate and inadvertent introduction op species from other regions but also through land-cover change, pollution and especially through rapid climate change.[5]

Novel ecosystems have unknown functional characteristics and may be difficult or impossible to return to a prior condition. James Harris et al. argue that if we insist on using only local species in restoration projects, we run the risk of "a genetic dead end that does not allow for the rapid adaptation to changed circumstances that may be needed if climate change scenarios proceed as predicted" (Harris et al. 2006, 174). Therefore, invasive species are no

[4] A niche is the role or function of an organism in a community of plants and animals. Each community, especially an island, has a limited number of niches and therefore can hold only a limited number of species. In a certain area, no two species can occupy the same niche for long; the one that is better adapted will win the competition for food and habitat and will cause the other to leave or become extinct.

[5] "If climate changes over the next 100 years as current models predict, surviving species throughout much of Earth's land area will not simply migrate north and south en masse as unchanging communities… Instead, they are likely to be reshuffled into novel ecosystems unknown today" (Fox 2007, 823).

longer an anathema to these and many other authors; they can create new ecosystems and communities that have never occurred before and that do not require human intervention to persist (Schaefer 2009). To recognize that some ecosystems are transformed irreversibly and that invasive species will persist in some cases “may seem to some to be a defeatist approach” (Hobbes et al. 2006, 5). On the other hand, “valuing the past when the past is not an accurate indicator for the future may fulfill a nostalgic need but may ultimately be counterproductive in terms of achieving realistic and lasting restoration outcomes” (Harris et al. 2006, 175). In the face of unprecedented environmental change, restoration to a historic standard is becoming more and more anachronistic (Jackson and Hobbes 2009).

Some authors go beyond the idea of managing novel ecosystems and advocate the purposeful designing of ecosystems (Palmer et al. 2004; Temperton 2007). These authors stress that the need for a shift from a ‘historic’ to a ‘futuristic’ approach to restoration is greater than ever (Choi 2004; Choi 2007; Choi et al. 2008). Because environments are irreversibly changing at an unprecedented rate there is no alternative to the creation of ‘designer ecosystems’, i.e., synthetic systems consciously invented to achieve ecological, social, and/or economic goals (Martinez & Lopez-Barrera 2008).

Hubris or humilty?

The shift to ecological design is unavoidable when the past is no longer an accurate indicator for the future. But the notion of designer ecosystems could also reinforce the “misguided faith in the hegemony and infallibility of the human power to control the natural world”, to use Eric Katz’ words. In their discussion of translocation (assisted migration) of species as a possible technique to prevent extinction under conditions of rapid climate change (see Hoegh-Guldberg et al. 2008), Harris et al. recognize the danger of becoming more comfortable with serving as active agents in ecosystems to the extent where maintaining the status quo or returning ecosystems to some past state are no longer viable options.

> It is one matter to watch change happen in ecosystems and wonder how and how much to intervene, and quite another to become a determining agent in that change. How smart can we be, and how much hubris is there in presuming that we can understand and predict ecological change? (Harris et al. 2006, 171)

Hobbes and Cramer contend that even well-intentioned interventions in complex ecosystems can have unforeseen and undesirable consequences. “There may be a hint of hubris in assuming that we always know (*a*) what the problem is, (*b*) how to fix it, and (*c*) what the end result should be” (Hobbes and Cramer 2008, 54; cf. Hobbes et al. 2009, 604). William Throop has also raised doubts about the consequences of restoration once we shift the focus from a historic to a futuristic approach. Because our understanding of historic, pre-disturbance ecosystems is normally far greater than for most novel systems, we should question our ability to design ecosystems.

> The idea of designing ecosystems (…) seems linked to the hubris that is often responsible for the ecosystem degradation we are trying to correct. If arrogance is part of the problem, then the humility involved in returning nature to a pre-disturbance state, where possible, may be part of the solution (Throop 2004, 47).

The fear for hubris and the appeal to humility arise from the suspicion that we might lack the measure of control and power over nature that is required to successfully and safely manage novel systems, let alone to design ecosystems entirely *de novo*. Paradoxically, the shift from ecological restoration to ecological design goes hand in hand with another important trend which contradicts the idea (and ideal) of absolute control over nature.

2. The collapse of the ideal of absolute control over nature

Over the past decades, the ideal of total control over nature has crumbled as a result of the shift within ecology from equilibrium theory to non-equilibrium theory, and the associated change in perception of ecosystems from static entities with a linear and predictable development to dynamic entities that evolve along non-linear and unpredictable trajectories. The dynamic and non-linear nature of ecosystem development was already recognized by Gleason in the early 1900s (section 1); it became the focus of renewed attention in the 1970s through the work of Robert ('Bob') May and C.S. ('Buzz') Holling, who is considered the father of the so-called 'resilience approach.'

A core concept of this approach is the notion of an 'adaptive cycle.' The central idea is that ecosystems tend to move through cycles of change. These changes are not entirely predictable, but often follow a pattern in which four phases are commonly observed. Generally, they move from a rapid *growth* phase through to a *conservation* phase in which resources are increasingly unavailable, locked up in existing structures, followed by a *release* phase that quickly moves into a phase of *reorganization*, and hence into another growth phase.

Another core concept of the resilience approach is 'panarchy' (e.g. Gunderson and Holling 2002). This notion refers to the dynamic interactions among system scales. A system at a particular scale will usually be comprised of smaller subsystems as well as being nested within larger systems. Resilience theory assumes that the four-phased adaptive cycle operates at all scales of a system, from the smallest to the largest, with processes occurring on one scale influencing system dynamics at other scales. Larger scale systems can, for instance, help provide the 'memory' that allows the next adaptive cycle of smaller scale systems to be similar to the current one.

Resilience versus stability

In equilibrium theory "stability was the norm, and disturbance was bad" (Wallington et al. 2005). To maintain a predictable world and to assure a stable maximum sustained yield with as little fluctuations as possible, prevention of disturbance was seen as prerequisite. But stability is usually inversely proportional to resilience, defined as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling 1973, 14). In other words, high stability might result in low resilience so that some inevitable unexpected event that previously could be absorbed can trigger a sudden dramatic change and loss of structural integrity of the system.

In the resilience approach, disturbance is considered to be an inherent feature of the internal dynamic of ecosystems. Disturbance is required to initiate the release phase of a system. This is usually a phase of 'creative destruction' that is quickly followed by the reorganization phase, which leads once again to a time of growth. Disturbances facilitate the renewal of ecosystems; their suppression might reduce the resilience that will prevent a system to collapse and 'flip' into another state with less valued components.

The resilience approach is fiercely opposed to the command-and-control methods and measures that are typically employed within the stability approach that is still common in natural resource management. Command and control attempts to turn complex, nonlinear systems into predictable, stable and economically efficient systems by replacing natural ecological controls with engineered constructs. A frequent result of command and control is reduction of the range of natural variation of systems which goes hand in hand with a decrease of resilience and an increase of vulnerability to shock, surprise and stress. To avoid this 'pathology of natural resource management' (Holling and Meffe 1996), proponents of the resilience view advocate a learning-by-doing approach to management, namely ‘adaptive management’ (Holling 1978; Walters 1986; Lee 1993), in which, among other things, small scale perturbations are allowed to operate in order to prevent large scale disruption.

Although adaptive management still awaits broad adoption, there are already some important examples were the failure to meet preset targets through command and control have forced agencies and organizations to move in the direction of a less rigid and more flexible management style. I will present three of these examples to give an impression of the new mode of control that seems to be typical of this management style.

Fire control

The new science of forestry that emerged about a century ago perceived fire as an evil force, antithetical to sound forestry, and condemned the practice of purposeful burning by Native Americans and settlers as a sign of loose morals. Here is a typical remark from Gifford Pinchot, the very influential head of the U.S. Forest Service. In 1910, he said:

> In the early days of forest fires, they were considered simply and solely as acts of God, against which any opposition was hopeless and any attempt to control them not merely hopeless but childish. It was assumed that they came in the natural order of things, as inevitably as the seasons or the rising and setting of the sun. Today we understand that forest fires are wholly within the control of man (quoted in De Golia 2002, 18)

Ironically, 1910 was also the year of the great fire complex in Idaho and Montana. Five million acres burned that summer all across the national forests. Fire was far from being under ‘the control of man’. As complete fire suppression - to ensure a steady lumber supply - became more expensive and as it was realized that it was in fact an unattainable goal, purposeful burning was becoming an accepted technique. Between 1968 and 1985, federal agencies began changing their policies to allow for the ‘prescribed’ use of fire. The new policy has been described as ‘fighting fire with fire’.

Predation control

Also around a century ago, it became an accepted practice in U.S. national parks to control predation by large scale culling of large carnivores like wolves, bears and mountain lions. These predators were hunted and killed in order to produce a larger, more reliable supply of game species. However, the removal of carnivores happens to lead unavoidably to ecosystem simplification accompanied by a rush of extinctions. For instance,

> [w]ith the extermination of wolves and the near extermination of mountain lions sixty years ago in Yellowstone National Park, elk populations built up. Lacking of predators, elk grew lazy and careless, loafing in large herds in river meadows. Their behavior changed so much, it was hard to call them elk. Not only did they overgraze the grasslands, their browsing of willow shoots hampered beavers from reestablishing themselves in Yellowstone.[6]

Here, management also made a switch and now promotes the reintroduction of large predators. The new policy leaves it to large carnivores to control large herbivores. After reintroduction of large carnivores, the foraging patterns of large herbivores once again reflect their need to balance demands for food and safety by fear of predation and this has a beneficial impact on the biodiversity of particular areas.

Flood control in the Netherlands

A large part of the Netherlands lies below sea level or below the high-water level of the major rivers. To protect the land from floods, as early as the mid-14th century, a nearly completely

[6] http://www.rewilding.org/TopDownRegulation.html

connected system of dikes arose. However, with the land subsiding and water levels rising, the traditional approach to flood control – dyke reinforcements – has become inadequate. In 1996, the Dutch government therefore decided to abandon the traditional water policy of dike reinforcements. Instead of restricting rivers in straightjackets of dikes, the new policy of flood risk reduction is aimed at creating more room for the river and to restore the self-regulating capacities of water systems by allowing dynamic processes to run their course again. The *war on water* is being replaced by a *dialogue with water*, in which water is being treated respectfully by engineers who have replaced their authoritarian and technocratic attitude for a more modest and cooperative attitude.

Controlled decontrolling

In these examples, control does not disappear but only changes form. We need to loosen the reins, but that often demands more rather than less horsemanship. This can be clarified with an analogy derived from the civilization theory of Norbert Elias. Elias differentiates between roughly two phases in the western civilization process. In the period from 1200 until 1750 people learned to repress spontaneous reactions. In the following period they were expected no longer to simply repress their feelings and emotions but to express them in a 'controlled' way. This form of self-restraint Elias has called 'controlled decontrolling of emotional controls'. Analogously, we can characterize the new types of flood, fire and predation management as 'controlled decontrolling of ecological controls' (Klaver et al. 2002, 14). This formula makes it clear that giving the dynamics of water, fire and predation more room again is not an uncontrolled process, but asks for new, less rigid and more flexible forms of control.[7]

Terra incognita

The success of the strategy of 'controlled decontrolling' depends on ecological control mechanisms and the self-regulating and self-organizing capacities that govern ecosystem dynamics. However, anthropogenic-driven global environmental change results in ongoing degradation and destruction of these very ecological controls.[8] This has a detrimental effect on the resilience of ecosystems. For instance, loss and fragmentation of natural habitats, which is caused by agriculture, forestry, urbanization, construction of infrastructure and tourism, often affect the large-scale and slower systems that foster the 'memory' of small-scale and faster systems (see section 2). Such a loss of memory makes it difficult or impossible for systems to recover after shock or surprise and to replicate earlier adaptive cycles. Disturbance events will usually not initiate the system's reorganization in such a way that the next adaptive cycle is similar to the current one, but may cause a system to suddenly 'flip' into an entirely new, possibly less desirable form.

In other words, nature is running out of control, leading us into uncharted territory where our understanding of how systems work under current conditions, which is already rudimentary and incomplete, is no longer a reliable compass for the future. With respect to the

[7] The idea that we should replace coercive command-and-control methods and measures by a more cooperative approach is also present in new research areas as environmental design and industrial ecology, where nature is taken as model for making things (Keulartz & Korevaar 2009). This idea of 'learning from nature' was vigorously put forward by Janine Benyus in her 1997 book *Biomimicry; innovation inspired by nature*. Biomimicry is "a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems." Yet another area where the idea of "learning from nature" has taken hold is genomics. Here, philosopher Peter Sloterdijk (2001) observes the emergence of "a non-dominant form of operativity", which has been anticipated in ecology and complexity theory and for which he has suggested the name "homeotechnology".

[8] Man's impact on the environment is omnipresent to such an extent that the Nobel Prize winning expert in atmospheric chemistry Paul Crutzen (2002) has introduced the term 'anthropocene' to characterize the present era. In 2008, the Stratigraphy Commission of the Geological Society of London decided, by a large majority, to examine the possibility to formally include this term in the Geological Time Scale (Zalasiewicz et al. 2010).

management of novel and designer systems "ecological restoration researchers face a paradoxical challenge of developing predictive models from unpredictable nature" (Choi et al. 2008, 58). To the extent that ecological controls break down, the possibilities for 'learning from nature' will eventually vanish. As a consequence, ecologists acknowledge "that restoration goals are determined by us, not by nature" (ibid., 60). As the course of nature becomes more and more unpredictable, "the choice of restoration and management goals should ultimately be a societal one" (Wallington et al. 2005). This leads us to the third trend within conservation and restoration science.

3. Ecosystem goods and services

The awareness that ecosystems are increasingly unlikely to move through sustainable cycles, and that nature loses its power to guide our management decisions, goes hand in hand with the emergence of the concept of 'ecosystem services'. Ecosystem services are the benefits people obtain from ecosystems; they generate "what we want" (Seastedt et al. 2008, 550) in an era of unprecedented global environmental change. In this respect, ecosystems are living natural capital assets that, if properly managed, produce a flow of vital services to human societies.

In 2005, the very influential UN *Millennium Ecosystem Assessment* report concluded that degradation of ecosystem services presents a significant threat to achieving the UN's Millennium Development Goals, worsening poverty and causing social conflicts. At global scales, 60% of the ecosystem services on which people depend were found to already be over-exploited or threatened.[9] The report uses four different classes of ecosystem services: *provisioning* ecosystem services (including food, fiber, fuel, and genetic resources); *regulating* ecosystem services (climate regulation, water purification, pest regulation, and pollination); *cultural* ecosystem services (spiritual, religious and aesthetic values, inspiration, recreation, and ecotourism); and *supporting* ecosystem services (that are necessary for the production of all other ecosystem services).

The concept of ecosystem services rapidly gained popularity during the 1990s, which saw an explosion of books and articles dealing with and expanding the concept (e.g. Costanza et al. 1997; Daily 1997). There is a broad and still growing consensus among ecologists that the restoration of ecosystem goods and services might be the best alternative for the "nostalgic recompositions of the past" (Choi 2007, 352). "Ecological restoration finds new moorings in emphasizing restoration of ecosystem function, goods, and services" (Jackson and Hobbs 2009, 585). Although the concept of ecosystem services appeals to many in the scientific community and beyond, it is not a panacea for our current natural resource management ills.

Anthropocentrism

Some critics have expressed concern that the focus on ecosystem services, by definition a purely anthropocentric approach, may not protect biodiversity sufficiently because it emphasizes the instrumental value of biodiversity at the expense of its intrinsic value. Rather than addressing taxonomic diversity, the ecosystem services approach is interested in functional aspects of diversity. Such functional aspects include functional group diversity and functional response diversity. *Functional group diversity* refers to groups of organisms that perform different ecological functions (e.g. seed dispersion, predation, grazing, pollination,

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[9] On a European scale, the trend for biodiversity also points downwards. The report *Ecosystem Services and Biodiversity in Europe*, compiled by the European Academies Science Advisory Council in 2009, concludes that we are living through a period "in which ecosystems are being degraded and biodiversity is being lost at rates not seen in human history" and that there are "fears that this will have significant consequences for the flow of the services nature provides".

and nitrogen fixation) in an ecosystem. *Functional response diversity* refers to the variability in response of species within functional groups to environmental change. Functional response diversity plays a special role in ecosystem resilience. A system with a single species supporting an important ecological function is less resilient than a system where several species support the same function. So, an obvious question is: “Will an ecosystem service-oriented approach value functionally redundant species only as insurance against risk to other species?” (Chan et al. 2007, 61)

Commodification of nature
Yet another criticism of the ecosystem service-oriented approach concerns the introduction of market-based mechanisms in biodiversity policy. It is feared that turning restored ecosystems into commodities will have perverse effects. It implies “that nature is only worth conserving when it is, or can be made profitable (McCauly 2006, 28).

The ecosystem services most readily incorporated into a socioeconomic framework are the provisioning services like food, timber and fresh water. Regulating services (e.g. carbon sequestration, storm protection and pollination) or cultural services (e.g. recreation and spiritual values), on the other hand, are often overlooked because they are not traded on the market or internalized in traditional cost benefit analyses (F. Stuart Chapin III 2006, 16638). There is a risk of it getting stuck in a market mindset and of ‘cherry-picking’ by politicians and industry. Payment for ecosystem services schemes can encourage monoculture development.

Tradeoff asymmetry
So, in spite of the general belief among conservationists that win-win solutions can always by found, increases in provisioning services typically result in decreases in regulating and cultural services. But this is not the only tradeoff asymmetry. From a series of case studies, Bulte et al. have concluded that ‘Payments fore ecosystem services’ (PES) cannot always serve to both eliminate poverty and improve environmental quality. “Achieving two objectives for the price of one policy is tricky and depends on specific conditions” (Bulte et al. 2008, 249).

In fact, tradeoff asymmetry is the rule rather than the exception because, as Carpenter et al. have remarked, there generally is a disconnection between the location where the benefits are derived and the location where the costs are borne. Downstream lowlanders benefit from ecosystem services generated by upstream highlanders, and city-dwellers depend on ecosystem services generated far away from cities. As a special case of tradeoff asymmetry Carpenter et al. mention intergenerational inequities, “where actions taken in the present result in a loss of ecosystem services in the future” (Carpenter et al. 2009, 1309).

Final remarks

It is clear that there is ample reason to somewhat temper current enthusiasm for the ecosystem service-oriented approach. Perhaps the biggest challenge for this approach concerns the present confidence in our ability to consciously invent and design ecosystems that will serve our needs. At this stage in the era of the Anthropocene we are largely treading on *terra incognita*. The shift from a historic to a futuristic approach fatally coincidents with the decline of our ability to learn from nature, because we have to a large extent degraded and destroyed the very natural controls upon which sound adaptive management should be based. Our past experience and current knowledge are no longer valuable guides or reliable compasses for the future.

In this precarious situation we should avoid ‘putting all eggs in one basket’ and follow Jackson and Hobbs’ advice to continue and even accelerate our efforts to conserve and restore historical ecosystems. Because of the increasingly anachronistic nature of historical targets, Jackson and Hobbs consider this as a seeming paradox. But they nevertheless advocate the ongoing conservation and restoration of historic ecosystems in order to avoid or minimize the risk that things may go wrong because of our lack of understanding of novel or engineered systems.

> Restoration efforts might aim for mosaics of historic and engineered ecosystems, ensuring that if some ecosystems collapse, other functioning ecosystems will remain to build on. In the meantime, we can continue to develop an understanding of how novel and engineered ecosystems function, what goods and services they provide, how they respond to various perturbations, and the range of environmental circumstances in which they are sustainable (Jackson and Hobbs 2009, 568).

But, again, as in the case of functional response diversity, we may ask: should we be satisfied with an approach that values historic ecosystems only as insurance against risk to other systems, and that emphasizes the instrumental value of historic systems at the expense of their intrinsic value? Or should we try to maintain a vital connection between the past and the future, and look for a balance between conserved, restored, and invented ecosystems? (Palmer et al. 2005, 5)

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