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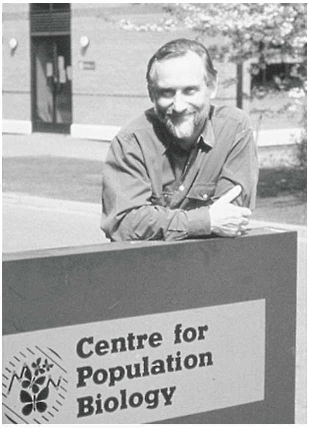

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THE SCIENCE AND NON-SCIENCE OF CONSERVATION BIOLOGY

Conservation biology is not a cosy, academic game. What we do matters, and the scale of the problem is daunting. Over the last few hundred years, human beings have steadily increased the rate of species' extinction, by perhaps 2 or 3 orders of magnitude above 'background' rates. Looking ahead, and by a variety of calculations, it is difficult to avoid the conclusion that extinction rates over the next 100 years will be at least 4 orders of magnitude faster than background rates in the fossil record (Lawton and May, 1995). Such rates of extinction may be unprecedented in the history of life on Earth.

Conservation science stands at the sharp end of this global mayhem, and offers some hope that the destruction will be less than it might otherwise be. Conservation action without good science to underpin it is like alchemy, or faith healing. Both sometimes produce desirable results, but you have no idea why, and mostly they don't. And yet there is a fundamental, and frequently unrecognised dilemma at the heart of conservation efforts, which the heat of the battle tends to obscure, rather than to illuminate. What do we wish to conserve, and why? A simple answer is that we want to reduce, or eliminate the impacts of human beings over at least part of the globe, to conserve remnants of what is 'natural'. Implicit, and sometimes explicit in these wishes is the assumption that there exists some pristine, Garden-of-Eden-like state for all ecosystems, from which they have been disturbed by human actions. But there never was a Garden of Eden that we should strive to save or recreate. Ecosystems change continuously at all time-scales, and the further we go back in time , the more different they become. Deciding what we want to conserve is not, therefore, a scientific question, because there is no bench-mark virgin state that we can refer back to. We may find this uncomfortable, but it is also true. Indeed recognising it may help to sharpen conservation objectives in a world made even more difficult by the looming threat of human-induced global climate change.

Let me start with a familiar example, but quickly make it less familiar. The fact that small, isolated populations are highly vulnerable to extinction, and that even large, isolated populations are at risk in the long term has lead to the development of population models by conservation biologists, designed to predict 'minimum viable populations' or MVPs. The reason that any isolated population (or indeed metapopulation) however large, is vulnerable to extinction is because all populations fluctuate in response to density independent perturbations - so called 'environmental noise'. Almost without exception, models designed to predict MVPs assume that this noise is random 'white noise' (by analogy with white light) in which all frequencies have equal power; static on the radio is white noise. It seems increasingly likely that real environmental noise is nothing like this. Rather it is 'coloured noise', often 'red noise' in which, as in red light, longer wavelengths predominate (Halley, 1996). More formally, real environmental noise is (roughly, and omitting a lot of technical detail) $1/f$ noise, in which the magnitude or the power of the noise is inversely proportional to its frequency, f. Little perturbations happen often, disasters very rarely, and minor catastrophes somewhere in between. How often have we heard conservation managers complain that they were well on the way to saving this or that endangered species when they were hit by an 'abnormal' or 'unexpected' event. There is no such thing. There is only $1/f$ noise.

This insight has two consequences. First, most predicted MVPs are probably too optimistic, with profound and depressing consequences for future extinctions. Second, as I pointed out earlier, there is no fixed, virgin state for any ecosystem. $1/f$ noise means that the longer we observe populations or ecosystems, the more they will change. 'Normal variation' (with a characteristic mean and variance) does not exist; $1/f$ noise implies that all ecological systems fluctuate within wider and wider limits, over longer and longer time periods. The implications for how we decide what to conserve are profound.

The world is now dotted with protected areas, in the form of nature reserves, national parks and wilderness areas - the names vary but the objectives are broadly the same - to carry a proportion of the earth's biota through into the next century and beyond. What many people fail to recognise, and which is therefore a source of endless confusion, is that the very establishment of these protected areas (the species or ecosystems to be targeted, where the reserves are, their size, and the degree of protection afforded to them) is not in itself a scientific process. Science may help to inform the process of establishment, but the decisions are ultimately political, ethical, aesthetic, even religious, and embrace much more than just scientific information. At its heart, conservation is not a scientific activity.

Moreover, even when a protected area is established, the dilemmas for science and society do not stop; if anything they become more intense. Except for some of the largest protected areas on earth, all these systems require some form of management, and in general the smaller they are, the more intensively managed they need to be. Protected areas are rarely intact hydrological units; their inevitable, growing isolation from surrounding landscapes disrupts a wide variety of processes, from natural fire regimes to the migration of species in and out of the area; invading, exotic weeds do not recognise park boundaries, and so on and so forth. In smaller protected areas, edge effects become significant and ecosystem process may be drastically altered. And virtually all protected areas, whatever their size, need management policies for people, be they indigenous people with traditional land-use rights that may not be sustainable as their population grows, or visitors from outside who wish to walk, bungie-jump, photograph and shoot things.

How are the management policies to be decided? The answer is with great difficulty, because the decisions about what to manage for are again not, ultimately, scientific decisions. They too are political, economic, ethical, aesthetic and religious decisions, but they are not scientific ones. Let me try and explain why.

First, science is clearly involved in delivering effective management once management goals have been defined. Habitat restoration, wetland recreation, changes in the fire regime, culling ungulate populations or any other management practices all require an underpinning of ecological science, both to carry them out effectively and to predict their consequences. Science can also inform managers, politicians, or citizens of the consequences of continuing with some particular course of action, or of changing or stopping it, and hence can help to set management objectives - to reduce or increase fishing quotas, or timber harvesting, or to change the water abstraction regime and so on.

The problem is that none of these many and varied activities, scientifically sophisticated and difficult as they may be, tell society what the ultimate management goals ought to be. What do we want to manage for? Nature conservation - why? Endangered species - which ones? Ecosystems - in what state? Sustainable fisheries - I would rather put the money in the bank, because money grows faster than fish. Resilience - meaningless. The list of difficult questions is endless. Nor are the answers obvious, because one person's burning objectives are another person's obstacles to a better life. In other words, at its heart, setting management objectives for conservation is not a scientific activity. There are even those in any nation for whom conservation in any guise is not on the agenda. Somehow, that ill-defined body known as 'society' has to decide what its environmental and conservation objectives are, and then act accordingly. To repeat myself, science can help inform that choice, but it cannot make it.

This problem rears its ugly head in the vexing, albeit apparently simple question of ecosystem management for nature conservation. In recreating, restoring or managing existing ecosystems, what is the baseline state we wish to hold to? 'Pristine' is not an answer, because as we now know, there is no such thing. Unaffected by human beings, ecosystems change continuously. *1/f* environmental noise guarantees that this will be so. Ten thousand years ago, the major heathland UK National Nature Reserve known as Chobham Common, just a few mile away from Silwood Park, was a barren tundra (ice ages occur infrequently, but with great power). Then, somewhere between roughly 5 and 10 thousand years ago it was progressively birch, pine and oak-hazel woodland, and finally under the combined human impacts of felling, fire, primitive agriculture and grazing it turned into heathland. Now, left unmanaged, it reverts back to scrubby birch-pine woodland. But 'society' has decided that heathland is more valuable from a nature conservation point of view than birch-pine woodland, and Chobham is one of a number of heaths actively managed to maintain and to restore this threatened ecosystem. But the decision has no rational basis in science. We might just as easily have decided that trees look nicer than heather, and changed the management regime accordingly.

In sum, any decision about what state to manage an ecosystem for in conservation is arbitrary. Whatever we choose, the system was probably not like that 500 years ago, and certainly not like it 5000 years ago. The best we can do is to try and minimise modern human impacts that impinge upon the system from without, and to keep Nature's options open. This is easiest in very large areas, and becomes more and more difficult as the size of a protected area declines. Management in small reserves (from a few 10's to a few 1000 ha) is often dominated by the need to maintain habitats for one or a handful of endangered species, and more resembles gardening than anything else. And of course, deciding *which* species to nurture has more to do with species' charisma, and human preferences than science. Do not be fooled by clever mathematical algorithms designed to maximise global species richness, or higher taxonomic diversity, or whatever, in the placement of protected areas. These are simply good science applied to value judgements, with all their human foibles. I personally happen to think that we should be concentrating conservation efforts on the earth's most vulnerable habitats and species, followed by areas of high endemism and/or unusually high richness. Others would order their priorities differently.

Whilst I am on these knotty problems, one more point is worth making. There is an implicit tendency in much of the thinking in conservation biology to assume that species are the vulnerable entities, and that ecosystems are somehow more permanent. Most readers probably feel comfortable with the notion of conservation efforts being directed towards the reintroduction and re-establishment of species previously exterminated from surviving ecosystem remnants. Such work is vital, skilled and exciting. But on longer time-scales, it is also an illusion. In reality, it is species that are the constant elements and ecosystems that are transitory. Over long time scales, fossil and subfossil remains of flora and fauna show that whole sets of species do not respond as tightly integrated units to natural (*1/f*) variation in the earth's climate. Communities do not move together. Rather individual species respond in a highly idiosyncratic manner. Many extant species combinations and ecosystems have no historical equivalents; and species combinations and ecosystems existed in the glacials and interglacials that have no modern descendants. The same pool of species can apparently create a variety of ecosystems, depending upon the vagaries of migration and geographic isolation, and the particular climatic, geological and other environmental features that are unique to each time and place on earth.

In the very long term, it follows that species conservation (with all its attendant subjectivity and value judgements), and the vagaries of luck and politics will determine what kind of ecosystems might exist, because ecosystems are more ephemeral than species. To use an analogy, the massive, human-induced species extinctions that confront us over the next century will strip Nature's tool-kit of thousands of useful parts, with who-knows-what consequences for her ability to build the new ecosystems of the future. We must therefore do what we can now to preserve both species and ecosystems; ecosystems because species need them in the short-term, and species because they make ecosystems in the long term.

But the final twist is this. If ecosystems change continuously in the absence of people (human beings did not invent *1/f* environmental noise), they will do so even more in a world threatened by human-induced global environmental change. Human beings are not creating global environmental change where none existed before; we are speeding up, magnifying and altering the nature of the change. We are part of *1/f* noise with a vengeance. To recognise this is to realise that the heart of conservation biology is not to restore the Garden of Eden, or to maintain samples of what is natural, because there is no rational scientific basis on which to define 'natural'. Our deepest, and most difficult responsibilities are to create conditions that allow ecosystems to change, as they have always changed, but in a world in which changes are accelerating, novel and multi-faceted, and somehow to manage this with the minimum loss of species and the least damage to ecosystem processes. Scientifically, the challenge is mind-boggling. Politically, it is an exceptionally difficult message to convey to policy makers and to the general public, and it won't go down well with many dedicated conservationists. But that is the future, and we must try.

References

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Editor's Note: This paper was originally published in *Oikos 79*:3-5 (1997), and is reproduced here with permission. Dr P.H. Enckell's kind co-operation is gratefully acknowledged.