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Successes, failures, and challenges in protecting biodiversity: DOC and the next 20 years

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Abstract

Although the Department of Conservation has often been strikingly successful, particularly in managing very small populations and eradicating invasive introduced vertebrates, its normal modus operandi – managing threatened species individually by seeking to redress the idiosyncratic causes of their declines – may be usefully supplemented by attempting to manage entire ecosystems to favor many native species simultaneously and to disfavor whole suites of invasive species. It is also likely that greater interaction with social scientists will help to ameliorate controversies that arise over conservation projects, particularly those that entail removing introduced vertebrates. However, neither ecosystem management nor engagement of social scientists will be a panacea. In particular, it may well often prove impossible to manage whole ecosystems so as to save threatened species while allowing substantial human use for harvest or other purposes, and there will probably always be at least a few opponents to any conservation measure, simply because of the variety of stakeholders that may be affected.

Key words: adaptive management, Department of Conservation, ecosystem management, eradication, introduced species, invasive species, multiple use, New Zealand

Introduction

The Department of Conservation (DOC) has been an inspiration to conservation biologists worldwide. Even the Conservation Act establishing it in 1987 was inspiring. The very idea was heretic, that an entire agency could be established to manage resources not to produce some product, like wood or fish or minerals, but simply to conserve species, even those of no obvious economic value. That scientists and managers from various agencies could all be brought under one umbrella for the common purpose of conservation was almost unheard of.

During the first decade there were some rocky patches, both fiscal and operational (Napp 2007), but even in its infancy, DOC was a productive and influential source of conservation biology research and publication, with hundreds of reports, papers, journal articles, and entire books. My first participation in a DOC project was in 1989, when a superb conference on ecological restoration of islands was held in Auckland (Towns et al. 1990). Since then, I have interacted with DOC and its researchers on many occasions, and I never fail to marvel at how this mid-sized department of a small country has not only had some striking successes in dealing with New Zealand conservation issues but has become a world leader in some aspects of conservation, particularly management of dwindling threatened populations and invasive introduced species. For example, the rescue of the black robin (Butler and Merton 1992) is known worldwide as a rescue of an endangered species, while the achievements of DOC in eradicating rats from islands of increasing size, all the way up to 115 km^2 Campbell Island in 2001(DOC 2003, Towns et al. 2006), are legendary.

After 20 years, it seems like this is a good time to consider the next two decades of DOC. I am struck by the fact that the very issues that surround DOC today and will help to shape its future are ones that confront conservation globally, including the role of conservation biology in conservation. I believe these fall into two broad categories.

Single-species management vs. ecosystem management

The first is the issue of the scale at which conservation measures should be directed. Generally, management for conservation purposes through the early 1990s was overwhelmingly management of single species and consisted of identifying species in trouble, figuring out what the problem was, and trying to do whatever was necessary to save them. These measures were heavily tailored towards the specifics of each case – what specifically was causing the threat to a particular species. The research associated with conservation management was also generally highly specific and entailed learning a lot about the biology of particular threatened species; this research was often in the vein of traditional natural history.

By the early 1990s, as DOC was gathering steam, this approach came under assault from two different directions – the first was that it was too expensive, cumbersome, and inefficient to try to save one species after the other after the other, and the right way to manage for conservation was to manage entire ecosystems for conservation along with other goals, especially economic ones, like agriculture, forestry, and fisheries (Swank and Van Lear 1992, Morrissey et al. 1994). The other criticism was that it was not very scientifically gratifying or efficient to search for the idiosyncratic reasons why each species was threatened, when there may be universal factors predisposing all, or most, threatened species to be threatened (cf. Simberloff 1988). Nevertheless, this single-species approach still seems to dominate DOC's management programs, so a logical question to ask is whether a shift in one or both directions is warranted in the future.

With regard to the second contention – that there are general threats to small populations, just by virtue of their being small, and we should focus our attention on these general threats – Caughley (1994) observed that conservation approaches to species consisting of one or a few small populations tend to fall into two paradigms, the small population paradigm and the declining population paradigm. The small population paradigm sees problems associated with such species as generic and inherent in any small population – demographic and genetic stochasticity and the like. This paradigm was started or at least heavily influenced by the application of the theory of island biogeography to conservation beginning in the mid-1970s, and it became the basis of the idea of the minimum viable population size (see Shaffer 1981, Simberloff 1988). It was also fostered by the rise of conservation genetics, which initially focused on general problems of inbreeding depression and genetic drift in small populations (see Simberloff 1988). The declining population paradigm, by contrast, seeks idiosyncratic reasons that led what were presumably once common, widely distributed species to become sparse and restricted, then attempts to remedy or compensate for them. This appears to be the paradigm that DOC generally operates under.

Observations of a few species that probably never had more than one or a few small populations cast some doubt on the small population paradigm. One example is the Devil's Hole pupfish (*Cyprinodon diabolis*), endemic to a single spring in Nevada, USA with a surface area of ca. 200 m^2. Its population has fluctuated between ca. 200 and 600 individuals (United States Fish and Wildlife Service 1980). The population has the misfortune of being located near Las Vegas, and it declined in the late 1960s because irrigation pumping lowered the water level. There is no evidence that generic small population threats (e.g. demographic and genetic stochasticity) are operating, but several management procedures have aimed specifically at the pupfish, which would surely be extinct without them – maintenance of water level, establishment of a captive "insurance" population, security fencing, etc. If its habitat is not destroyed, there is no reason to think the pupfish is threatened by virtue simply of having a small population.

Many species have been successfully saved (at least for now) by management targeting specific, idiosyncratic causes of decline; cf. Caughley and Gunn (1996). The classic case is the Chatham Island black robin (*Petroica traversi*), once reduced to five individuals and saved by heroic activities including moving individuals to new islands and foster-rearing by another species (Butler and Merton 1992); there are now ca. 250 individuals. On the other hand, I am unconvinced that any species in nature has been saved by activities guided by the small population paradigm. One could, of course, argue that genetic or demographic stochasticity (forces envisioned in the small population paradigm) would ultimately have done in the black robin, but the death rattle of the final five individuals would have been just a detail. The real cause of the extinction would have been whatever reduced the population to five individuals in the first place – the combination of habitat destruction (including fires), introduced species, and perhaps hunting and other harvest.

Another impressive DOC example of traditional single-species management is the recovery of the North Island kokako, *Callaeas cinerea wilsoni* (Innes et al. 1999). This case is unusual because true adaptive management was employed. Suspected causes of the decline of this bird were predation by introduced predators and competition with introduced mammalian herbivores. Three forests (1000 – 3000 ha) were assigned intensive pest management treatments for eight years. There was no complete control and little replication, typical problems in large-scale adaptive management, but partial control was achieved by applying pest management to one of the forests for just the first four years and to a second forest for just the second four years. Results implicated predation as the threat, and extensive predator management has resulted in a promising recovery.

The key legacy of the small population paradigm is population viability analysis (PVA) to predict extinction risks and compare management options for threatened species. It is controversial, with some authors (e.g. Brook et al. 2000) citing useful applications and others (e.g. Lindenmayer et al. 2003) pointing to debilitating shortcomings. As currently formulated, it cannot adequately account for aspects of movement and connectivity of particular populations in particular landscapes (L. Fahrig, pers. comm., 2007), but it is well-ensconced in some management circles (though not in DOC), and one may hope for improvements.

The second challenge to traditional single-species management is the argument that it is too expensive and inefficient and that we can achieve economies of scale by managing entire ecosystems for both conservation and other uses simultaneously. The main management tool is usually treatment of entire regions and ecosystems so as to simulate natural processes, such as disturbance regimes, as closely as possible. Ecosystem management exploded on the scene in the mid-1990s, quickly becoming the official policy of many resource agencies (Christensen et al. 1996, Meffe et al. 2006), but it has proven to be problematic, for five main reasons:

1) Whereas single-species management usually has a clearly defined objective – maintenance, increase, or decrease of a particular species – ecosystem management has at times been associated with vague, undefined goals, such as "ecosystem health" (Simberloff 1998). And some literature on ecosystem management sees ecosystem processes in their own right as the goal, even though surely maintaining processes should be a means to an end – maintenance of one or more particular species.

2) Ecosystem management is often associated with the concept of adaptive management – project as experiment (Walters 1986, Walters and Holling 1990) – which is also problematic in

practice. The kokako project is one of the very best applications of adaptive management to conservation, but here it was applied to single-species management, not ecosystem management, and it was bedeviled by difficulties in replication. Perhaps the best examples of attempting to manage entire ecosystems adaptively come from Australian fisheries (Sainsbury 1988, Sainsbury et al. 1997, Mapstone et al. 2004), but even here there were similar problems of replication and control. Another problem with adaptive management is that it is often very loosely defined (cf. Lee 2001, James 2004), to the point that it sometimes appears to mean that, if something does not work, try something else. It is rarely rigorously practiced in an experimental mode, as was originally proposed (Stankey et. al. 2003).

3) Ecosystem management is quite new, so there is no extensive catalog of attempts and results with which to assess its success.

4) The main operational precept of ecosystem management – maintain a semblance of natural processes – sounds straightforward but is often technically difficult.

5) Often management to simulate natural processes, like fire or hydrological cycles, is simply not compatible with economic goals, such as agriculture or fisheries, at least on the scales that economic interests demand.

What one frequently sees nowadays is a mixture of traditional single-species management, usually under the declining population paradigm, and aspects of ecosystem management that might benefit other species than the main target and might also allow a degree of some economic activity. A good example is the evolution of management of the red-cockaded woodpecker (*Picoides borealis*) in the southeastern USA (Simberloff 2004). An iconic species listed quickly under the US Endangered Species Act, it has generated intense conflict between forestry interests and conservationists. Originally a widespread bird in the Southeast, it dwindled to a population size of ca. 15,000 by 1970, in several remnants of what had been a largely continuous forest of ca. 25 million ha of longleaf pine (*Pinus palustris*). Suitable habitat now consists of a few hundred ha in scattered tracts of primary forest, plus ca. 4 million ha of second-growth forest of varying degrees of suitability for the woodpecker, which nests in cavities excavated in old, dying longleaf pine trees. Such trees became rare as longleaf forest was replaced by farmland and production forests of faster growing trees (Tebo 1985). Longleaf pine forest is a fire disclimax; without frequent fires it is succeeded by various hardwoods. As the landscape has become increasingly anthropogenic, natural fires have been suppressed. The upshot is that absence of dying old trees means there are fewer suitable cavity trees, hardwood midstory encroachment in the absence of fire leads to cavity abandonment, and forest fragmentation leads to difficulties in finding habitat and in finding mates in isolated populations (James et al. 1997, Conner et al. 2001).

The current management plan of the United States Fish and Wildlife Service (2003) is advertised as combining single-species management and ecosystem management, but it centers on managing the woodpecker as an umbrella species – a species with such demanding habitat requirements that managing it by managing its habitat will save all other species (Simberloff 1998). The longleaf community includes several species of special concern, but only the woodpecker is targeted for individual management, including translocating individuals and installing artificial cavities. The other key part of plan – more frequent burning and retaining more old trees – accords with the ecosystem management approach of mimicking natural processes. However, even though an enhanced fire regime probably benefits the longleaf community as a whole, it will not suffice to maintain the woodpecker. Even with the suggested prescribed fire program, recruitment of saplings will not provide enough large, old trees (James et al. 2004), so single-species management will have to be implemented for the woodpecker. Furthermore, it is unlikely that this scheme could ever be integrated with substantial commercial forestry. It will probably require large blocks of forest removed from commerce altogether.

This final judgment on how to save the woodpecker captures my take-home message to DOC on traditional single-species management for threatened species: even though single-species management is often cast as old-fashioned in the rush to manage ecosystems (Simberloff 1998, 2007), and even though it is likely that managing ecosystems as a whole can be used to benefit whole groups of species and sustain some economic development, it is important to continue to manage at least some individual species and not to jettison management approaches that work simply because they seem old-fashioned. Particularly when a species has dwindled to the last few individuals in a fraction of the original range, it would be foolhardy not to focus directly on immediate actions to save that species because of a policy of managing entire ecosystems.

It is worth pointing out that managing established introduced species, which has been a hallmark of DOC programs and for which there are a growing number of successes worldwide, both in terms of eradication and maintenance management, has been practiced almost exclusively in a single-species mode (Simberloff 2007), though of course stringent exclusionary policies, as opposed to management approaches, generally target whole groups of potential invaders, and sometimes all potential invaders.

However, one can envision the possibility that some sorts of ecosystem management could exclude whole groups of invaders or manage them all at low density. For instance, in the longleaf pine communities discussed above, introduced plants are very scarce, even though they may be very abundant in surrounding areas. As an example, at the old-growth Wade Tract in south Georgia, virtually every introduced plant is found within 1 m of the single trail traversing the property (S. Hermann, pers. comm. 2005). Although it has not yet been proven, this is probably due to the frequent growing-season burns with which the Wade Tract is managed. This is the natural fire regime, and the native species have all evolved adaptations to it, while the introduced species have not. The management program was not specifically designed to keep the ecosystem free of invasive species, but it seems to function to do just that (although a fire-adapted invader, such as cogongrass [*Imperata cylindrical*], which is near the Wade Tract, could circumvent this management). The

Maungatautari project, in which a fence is designed to exclude all mammalian invaders, is a promising example of managing an entire ecosystem to exclude many invasive species simultaneously, as is the developing plan to eradicate all mammalian predators simultaneously from Rangitoto and Motutapu islands. I emphasize, though, that there are few if any other examples of ecosystem management to minimize established introduced species, while there is a growing roster of great successes of eradication and maintenance management of particular introduced species of animals and plants, and DOC projects are a prominent part of that roster.

Integrating sociology and psychology

If management approaches constitute one broad category of issues confronting DOC as well as the global conservation community over the next two decades, the other broad category is social issues. It is gradually becoming a common plea to say that we usually know enough biology to understand why species are disappearing, and even how to prevent their loss, but that we are stymied by our inability to bring the public on board and that we should enlist sociologists and psychologists because we biologists simply lack the expertise in dealing with such matters.

DOC frequently confronts such issues in dealing with particular cases, especially managing introduced species. For instance, 1080 is under assault (Monahan 2007). Even its use for as destructive an animal as the brushtail possum is controversial (Parliamentary Commissioner for the Environment 2000) – only 27% of the public finds it acceptable to use aerial dispersion of 1080 for this purpose (Fitzgerald et al. 2000), largely because of the painful death it inflicts. Now, in addition, deer hunters hate 1080 because of what they perceive as unacceptably high rates of incidental killing of deer (Monahan 2007).

Even aside from human concerns about harm to vertebrate targets of control measures, there is often a fear of any chemicals simply because they are chemicals, a sort of "chemophobia" that is even expressed in campaigns to prevent the use of herbicides against invasive plants. This chemophobia traces to the pathbreaking 1962 book by Rachel Carson, *Silent Spring*, that helped to found modern environmentalism. Carson was particularly concerned with non-target impacts of chlorinated hydrocarbons, and she was largely correct in her assertions, but we are several chemical generations beyond these pesticides now, and many modern pesticides and herbicides have few or no non-target impacts if used properly. Of course we should beware of subtle non-target impacts, and the problems of expense and evolution of resistance are real ones, but we should not let an ideological commitment to not using chemicals get in the way of what might otherwise be important and probably successful control measures.

As another example of public pressure impeding conservation, the eradication of kiore from Little Barrier Island was delayed by at least five years because of the arguments over the cultural and historic importance of these rats, in spite of compelling evidence of the harm they were causing to several species of animals and plants of conservation concern (Towns et al. 2006).

Of course, things could be worse – there are cases of expensive eradication efforts stopped by outright sabotage. For example, in Lake Davis in northern California, introduced northern pike (*Esox lucius*) in 1994 would have imperiled a number of threatened salmonid species if they escaped into the central California, as would have been inevitable. The California Department of Fish and Game attempted to eradicate this population by poisoning the entire lake with rotenone, but the effort led to enormous opposition, including death threats, and probably to sabotage by reintroduction (cf. Elmendorf et al. 2005). The massive opposition to the eradication was greatly exacerbated, if not completely spawned, by the ham-handed way in which the state agency simply said it was going to do this, without substantial efforts to educate the local populace about the dangers of the pike and the impacts of the eradication attempt. After the first failure, they have made a much greater effort to enlist public support, and it seems largely successful, with little opposition to a second attempt.

Similarly in California, animal rights activists attempted to sabotage an eradication project for ship rats on Anacapa Island (Towns et al. 2006). Lest one think that such lawlessness is restricted to California or to the entire US, deer hunters angry with plans to control deer populations have threatened to reintroduce possums to Kapiti Island and to release stoats on Codfish and Stewart Islands (Anon. 2003, Parkes and Murphy 2003).

There are also cases in which important eradication efforts have been stymied not by sabotage but by public opposition leading to legal impediments. Perhaps the most tragic case of this sort is the escape of the North American gray squirrel (*Sciurus carolinensis*) from a small infestation in the Piedmont of Italy. Introduced in 1948, it remained restricted to a small area until 1970, when it began to spread. This spread presents an enormous threat, as they would eventually pass the Alps into central and western Europe, and there is already the sad case in Great Britain of the decline of the native red squirrel (*S. vulgaris*) caused by the introduced gray squirrel (Gurnell et al. 2004). By 1996 in Italy, they had spread quite far but probably still could have been stopped, and a team from the University of Turin, in collaboration with the National Wildlife Institute, produced a plan for a test eradication on a small population in a park. The conservation organizations were informed, and the plan was modified to meet their concerns. However, certain radical animal rights advocates could not be satisfied, and in 1997 they went to court, sued the National Wildlife Institute, and managed to stop the entire project. It is now too late, even though the courts subsequently acquitted the National Wildlife Institute (Genovesi and Bertolino 2001, Bertolino and Genovesi 2003).

One would like to think that engaging experts in the social sciences and public relations could help convince the public to support or at least cooperate with programs to manage introduced species, and, to a point, this is probably true. The developing plan to eradicate rats from Great Barrier Island, complicated by the fact that 32% of the island is in private ownership, and owners have varying goals, is being approached with an abundance of caution and preparatory work. The latter entails continuing, in-depth interaction with all the various stakeholders (J. Ogden, pers. comm. 2007). It will be interesting to see if adequate buy-in can be achieved.

Certainly the second project to attempt to eradicate the northern pike from Lake Davis has much more public support than the first, and this is at least partly because of a concerted effort to educate the public, including by using public relations professionals. However, even in the Lake Davis case, the same people that apparently sabotaged the first eradication (sport fishermen) have made veiled threats to do it again (Elmendorf et al. 2005). And, even though it is quite likely that the Italians could have enlisted more sociological help in persuading the public of the need to eradicate gray squirrels, I doubt they could ever have convinced the most radical animal rights advocates. I have some experience with this movement – People for the Ethical Treatment of Animals (PETA) – in the U.S., and it is hard for me to believe that any argument based on the danger of some introduced vertebrate to biodiversity, even native biodiversity, would lead them to approve any practical control scheme for a vertebrate. The most they seem willing to accommodate is sterilization, and it is impossible to sterilize an entire population in the field. It is no accident that a disproportionate fraction of successful eradications have occurred on islands that are either uninhabited or have no organized animal rights communities.

Similarly, although many hunters may be convinced of the conservation importance of controlling introduced species, and probably more could be persuaded if further expertise in public relations were enlisted, I am skeptical that they all would. Certainly hunters, and especially native Hawaiian hunters, were at least as obstreperous an opponent as PETA was in opposing control and possible eradication of introduced pigs in Hawaii. Does anyone really believe that, even with all the evidence of the inimical impact of deer on New Zealand forest (e.g. Husheer et al. 2006), all deer hunters will willingly accommodate deer control?

A further complication, possibly one that could be ameliorated by sociological expertise, is that a number of conservation controversies become entangled with issues of rights of indigenous peoples. It was the Maori who impeded rat eradication on Little Barrier, on the grounds of their cultural significance, just as it was native Hawaiian pig-hunters who combined with PETA in an unholy alliance to stop pig control in Hawaii. Even aside from the importance introduced species may acquire for native hunters, native peoples may attach enormous cultural significance to hunting native species, even when the latter become threatened with extinction. Alaskan natives lobbied heavily and recently won permission from the International Whaling Commission to continue to hunt dwindling bowhead whale (*Balaena mysticetus*) stocks on the grounds that this is a crucial cultural practice (Anon. 2007). Native Americans from the Pacific Northwest are guaranteed by treaty fishing rights to declining stocks of several species of salmon (National Research Council 1996), and they exercise these rights.

I am not saying we should not strive to integrate social scientists into conservation management – far from it. In some instances it will be very useful. However, even the most thorough engagement of social scientists will probably not win everyone over to every conservation project, for ideological or other reasons, and we should try not to let otherwise important and promising projects be stymied by absence of complete public buy-in.

Conclusion

There are, of course, other ways in which DOC's modus operandi will have to evolve over the next two decades. For instance, most of its effort has been on terrestrial systems to date, and on the aboveground component of terrestrial systems. Clearly marine conservation deserves more attention, and the growing scientific work on the interaction of aboveground and belowground components of terrestrial ecosystems, including in crucial conservation sites in New Zealand (e.g. Fukami et al. 2006), suggests that conservation efforts should focus more than they do now on key aspects of belowground components. However, I am not nearly knowledgeable enough to elaborate a 20-year strategy for DOC. Rather, I have suggested some elements that should be included in such a strategy:

1) DOC has had many successes in conserving biodiversity in its short history. Its main strategy, intensive, species-specific management, has often worked well, and it should not be abandoned simply because this approach seems old-fashioned or too costly.

2) Exploration of managing entire ecosystems for conservation, often in conjunction with economic activities, is warranted, but it will not be easy to formulate realistic goals for such ecosystem management in the face of conflicts among many stakeholders. Formal adaptive management may aid the development of ecosystem management, but control and replication will be difficult to achieve, and the time scale needed to see if an approach is working may be many decades.

3) Achieving public understanding of conservation goals and support for management methods is important, and biologists and resource managers are usually not the people with the most expertise in how to engage the public. So conservation biologists and managers, DOC included, would do well to attempt to enlist social scientists in their action programs. However, we should not expect social scientists to end all controversy over our efforts, and we should try not to let a small minority of opponents block important conservation efforts.

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