Effectiveness of global protected areas: Perspectives for British Columbia

Michael I. Preston

106 - 991 Cloverdale Avenue, Victoria, BC. V8X 2T5

Introduction

In the 2003 United Nations List of Protected Areas, there are 102,102 globally identified protected areas covering 18.8 million km^2 of the earth's surface (Chape et al. 2003). Most are terrestrial, with marine areas comprising approximately 8.7 %. Presently, protected areas are perceived as having high conservation value (Brooks et al. 2004), but recently, it has been suggested that some protected areas may not be as effective as initially perceived, or they have low conservation value (i.e., the costs outweigh the benefits). Failure to evaluate effectiveness can have major implications for the maintenance and acquisition of protected areas, as well as for the allocation of limited management resources which protected areas (and the biota they contain) depend on.

Effectiveness monitoring is a relatively new discipline in conservation science, and it is only in the last 15 years that a substantial increase in the assessment of conservation projects has been undertaken (Saterson et al. 2004). Many studies have revealed that most protected areas either have inadequate design and coverage, lack sufficient management to address threats, or face increasing levels of environmental degradation (Ervin 2003). In an evaluation of 210 biodiversity monitoring projects funded by the Global Environment Facility, only 17 had sufficient information to assess the value of the project and its contribution to the conservation of biodiversity (Singh and Volonte 2001).

In this paper I examine the effectiveness of protected areas, drawing mainly from global examples. This approach in about global responsibility and begins to identify where weaknesses in protected areas exist, both globally and within British Columbia. For perspective, I summarize some of the protected areas systems in British Columbia and identify potential pitfalls that relate to ineffective conservation.

Assessing Protected Area Effectiveness by Monitoring

Protected area effectiveness can be measured at a variety of scales ranging from very small reserves that can be surveyed in their entirety, to the global protected area network, where many reserves may receive little or no monitoring. In this section I draw from specific studies of effectiveness monitoring and highlight some of the more important ideas that have thus far been addressed.

Over time, reasons for establishing reserves or protected areas in many areas has shifted from an anthropogenically-centered directive to one that is more biologically and ecologically driven. Presently, at the global scale, the purpose of protected areas is to preserve species, or perhaps more generally, at least to preserve wilderness areas and the biota they contain. If we consider the former, species preservation requires the encapsulation of all or part of a species' range, and perhaps more specifically, the part with the greatest number of individuals of that species per unit area. Therefore, it might be expected that the distribution of protected areas would be biased toward areas that are rich in species, or areas that include globally imperiled species. This does not appear to be the case.

In 2004, scientists recognized that although the expedience by which protected areas has grown in recent years is remarkable, the scientific basis and conservation value of those areas is largely unknown (Rodrigues et al. 2004). To address the problem, they conducted the first global gap analysis that would assess the effectiveness of protected areas in terms of species representation. The study included the use of species' ranges for 11,633 terrestrial vertebrates (4,735 mammals, 1,171 globally threatened birds, 273 freshwater turtles and tortoises, and 5,454 amphibians). Species were classified as "covered" (a substantial part of the species range occurs in a protected area) or "gap" (not occurring in a protected area).

Two null models were used to simulate a network of global protected areas similar to the existing one, but more evenly spread around the world (Rodrigues et al. 2004). Model I used "equal area sites" using the same size as the mean of all protected areas. Model II used "variable area sites" and drew from the same distribution of sizes as the current protected area network. A third model was designed to take into account the natural bias of tropical area richness (among species that occur in tropical or non-tropical areas only, but not both, 75.8 % occur in the tropics) and the disproportionately low representation of protected areas in the tropics (45.8 % of the global protected areas network) (Rodrigues et al. 2004).

There were 1,424 identified gap species and all but one was not represented in any protected area > 1,000 ha. Sets of species with smaller median range sizes had a higher proportion of gap species (e.g., amphibians) and threatened species were more likely to be classified as gap species than non-threatened species (Rodrigues et al. 2004). Countries with high levels of endemism were more likely to have more gap species than countries with few endemics. This relationship was largely independent of the amount of protected area, since the number of gap species tended to decrease with amount of protected area (Rodrigues et al. 2004). The presence of a gap species was mainly a function of the narrow distribution of that species. As expected from a species-area curve, there are generally fewer species with very large ranges, and many species with smaller ranges.

The models suggest that locations for future establishment of protected areas should not be in places with the lowest percentage of area protected, but in areas with higher levels of endemism (Rodrigues et al. 2004). Therefore, setting a benchmark value for conservation (e.g., 10 %) is not likely to be effective because it fails to recognize that species are not distributed evenly across the planet. Rodrigues et al. (2004) acknowledge that many protected areas today do indeed focus on sites with greater species richness, restricted range species, and threatened species, but that the current global network could perform better (e.g., a bias toward tropical areas to match higher level of endemism) at capturing gap species.

A major drawback to the Rodrigues et al. (2004) analysis is that it fails to examine such major taxonomic groups as marine and terrestrial invertebrates, plants, and fungi. At the group level, trophic ranking alone perhaps makes them more important for protection, especially considering their widespread importance for many ecosystem processes. However, at the species level, evaluation of status is hindered since many species or subspecies are as yet unknown, or their geographic range is not fully understood. A reasonable prediction is that many more species would be classed as gap species compared to covered species in the global modeling approach.

"...setting a benchmark value for conservation (e.g., 10 %) is not likely to be effective because it fails to recognize that species are not distributed evenly across the planet."

Next to species representation is the integrity, viability, or recovery of communities or species' populations encapsulated by protected areas. Some protected areas include the entire range of a species' distribution, but most only capture a portion. Newmark (1995) suggested that protected areas may become the final repositories for much of the world's biota. If this is realistic, it will be imperative to ensure that populations residing in those areas are viable.

Globally, and with the exception of protected areas that were initially created for human benefit (e.g., some national parks), most reserves today are designed for specific conservation purposes. Mainly, these are to protect some component of global or regional biodiversity, or to facilitate the recovery of one or more species whose populations are declining or are critically imperilled. For the latter, I address two important points:

1) population response post-reserve establishment; and

2) threats facing populations or communities that have long been encapsulated by reserves.

A growing number of studies are investigating the recovery of populations after reserve establishment. In particular, drastic declines in fish populations due to intense over-harvesting (Roberts and Hawkins 1999) are receiving increased attention. In a study by Mosquera et al. (2004), recovery of harvestable fish populations by marine reserves was evaluated for New Zealand, Tasmania, Tanzania, Kenya, Seychelles, the Mediterranean, Indian Ocean, Egyptian Red Sea, and the Caribbean. Data was compiled from 12 studies using 575 inside/outside reserve count estimates of 346 fish species in 56 families (Mosquera et al. 2004). The fish were divided into harvest and non-harvest species to avoid confounding results. For all species and all reserves, fish abundance was 3.7 times more abundant inside reserves compared to outside. The response was mainly attributable to increases in harvestable species and to larger-bodied non-harvest species that suffer heavy by-catch mortality (Mosquera et al. 2004).

In their study, the level of protection that each reserve had was unknown (i.e., some areas are illegally fished and enforcement is difficult). However, they did note that had there been a bias toward poorly enforced areas (i.e., where illegal harvesting did occur), then the potential value of marine protected areas for fish stock recovery is likely greater (Mosquera et al. 2004). In the Philippines, donkey's ear abalone (*Haliotis asinia*) was used to measure the effectiveness of protected area enforcement on population recovery (Maliao et al. 2004). For reefs with enforced protection, abalone density was significantly greater and body size was larger than for reefs that lacked enforced protection (Maliao et al. 2004). Mosquera et al. (2004) note that although reserve selection without *a priori* predictions have performed well, it is apparent that benefits are not realized by all species, and that reserve selection could be better.

National parks have a long history in North America, but consideration of threats to populations residing in them has only existed for about 20 years. I found two studies from national parks that investigated the integrity of native species richness and composition (Rivard et al. 2000) and extinction probabilities in mammal populations (Newmark

1995). First, Rivard et al. (2000) used the Canadian national park mandate, that species richness should not be lower than would be present naturally, and that changes in composition should be as low as possible, as a guide for measuring effectiveness. Specifically, they tested the idea that the regional species pool is influenced by climate (Turner et al. 1988, Currie 1991), and that species richness increases with park size (Wylie and Currie 1993).

The results were revealing. First, differences in species richness and changes in species occurrence among parks were related mostly to climate – specifically mean annual potential evapotranspiration. Thus, warmer, more southerly parks had greater change in species richness and community composition due to climate, even after controlling for original higher species richness found in those regions (Rivard et al. 2000). Second, landscapes within parks tended to be more similar to landscapes surrounding them in terms of vegetation cover, fragmentation, and infrastructure, regardless of park establishment date. Of particular interest was that species richness and alterations were strongly related to characteristics in the buffers, not just by characteristics of the park itself. Third, species with large home ranges (e.g., large carnivores and ungulates) were affected more by characteristics in the buffer than were species with small home ranges (e.g. frogs) that were more strongly correlated with park characteristics.

Support for negative effects of the buffer are also provided by Woodroffe and Ginsberg (1998). They investigated population extinctions for 10 species of large carnivore for eight major world regions containing numerous protected areas. The unfortunate, but rather unique, case for these carnivores is that they are all killed regularly by people outside the protected area. For all 10 species, the probability of local extinction was greater for small reserves than larger ones (Woodroffe and Ginsberg 1998).

It was also determined that for carnivores, populations of wide-ranging species were more likely to become extinct due to overhunting in regions outside the protected area, and that population size alone was a relatively poor predictor of carnivore extinction (Woodroffe and Ginsberg 1998). One weakness in this paper is that it does not give data on existing reserve sizes and what proportion of those reserves are expected to have extinctions for the species in question. This kind of information would seem imperative for implementing change.

Newmark (1995) rationalized that the primary cause of mammal extinction in national parks would be a combination of deterministic events (such as habitat loss and modification, and predation) and random events that occur both inside and outside the park boundary. He used current biogeographic and population lifetime models to review patterns of local mammal extinction in western national parks for *Lagomorpha* (hares, pikas, rabbits)), Carnivora (carnivores), and Artiodactyla (even-toed ungulates). He found that habitats adjacent to protected areas act as sinks for species that have large home ranges and subsequently wander into adjacent areas outside the protected area. Newmark (1995) concluded that although these parks are not true islands, the pattern of mammal extinction was consistent with the land-bridge island hypothesis. Thus, these parks were effectively behaving in such a way that they had become ecologically disjunct from the neighbouring area.

Protected Areas in British Columbia

Protected areas in British Columbia are many and varied, and the level of protection they are afforded is equally diverse. The best-known protected areas include national parks (Figure 1) and reserves, provincial parks, wilderness areas, marine protected areas, and ecological reserves (Figure 2). Wildlife Management Areas, of which there are 22 in British, do not have a "protected areas" designation (wlpawww.bcparks.gov.bc.ca), but they are included in this summary because of their primary emphasis on the conservation and management of "*wildlife, fish, and their habitats*". Other reserve areas, such as private sanctuaries, Ducks Unlimited wetlands, and regional and municipal parks are largely ignored in this report, because their function is largely for human-benefit. However, for some locations (e.g., George C. Reifel Migratory Bird Sanctuary) or specific purposes (e.g., Ducks Unlimited currently manages 69,102 ha in British Columbia; www.ducks.ca/province/bc/index.html), the potential conservation value should not be overlooked

Figure 1. The conservation benefits of Yoho National Park are enhanced by its size and adjacency with other national parks. Threats include increasing development, tourism, and hunting outside park boundaries. Near Takakkaw Falls, BC. 5 September 2004 (Michael I. Preston).

Figure 2. At White Pelican Provincial Park, the only regular breeding colony of the American White Pelican (provincially "Red-listed") in British Columbia is afforded protection. However, none of the surrounding lakes that this species depends on for feeding are protected. Stum Lake, BC. 25 May 1993 (R. Wayne Campbell).

for some species or populations.

The seven national parks comprise ~9,406 km^2. On the whole they are largely undisturbed, although some areas have had logging, commercial fishing, and low to moderate development. BC Parks operates provincial parks, marine protected areas, and wilderness areas (referred to as protected areas in Figure 3). They also operate ecological reserves. I have made the distinction between the two groups because the latter was developed for specific conservation targets (see www.ecoreserves.bc.ca for details).

In national parks, many plant and invertebrate populations are probably afforded adequate protection under normal conditions (i.e., they are not prone to disturbance by human-related factors within park boundaries). Many small mammals and songbirds (breeding and resident) are also probably reasonably protected. For larger bodied mammals and birds that range over a greater area, the likelihood of encountering disturbances increases. Thus, as demonstrated by Newmark (1995), those populations are likely prone to higher extinction probabilities via park externalities

Any population that occurs at or near the edge of a protected area is also susceptible to human-disturbance adjacent to park boundaries. Conversely, the probability of being near an edge increases with decreasing park size, thus resulting in smaller parks protecting fewer species or populations than larger parks.

In British Columbia, the majority (~70 %) of protected areas and ecological reserves are < 1,000 ha (Figure 3). Considerably fewer areas are very large. For instance, there are no ecological reserves > 50,000 ha and only 2.9 % of all areas tallied are > 100,000 ha (the largest, non-national park area is 947,026 ha). If we re-visit the results of the global gap-analysis (Rodrigues et al. 2004), 12.2 % of assessed species did not occur in reserves < 1,000 ha. Thus, for species with small ranges (either seasonally or permanently), a greater proportion of species are likely to be unprotected when the emphasis is on reserves that are < 1,000 ha. Globally, and perhaps provincially, this appears mainly as a consequence of poor reserve design, failure to recognize species distribution patterns, and an over-emphasis on jurisdictional rarities (see Bunnell et al. (2004) for a discussion of the latter).

Populations of species occurring in protected areas that are located near high-density urban areas may also be especially vulnerable. For example, in the vicinity of Boundary Bay, Robert's Bank, and Sturgeon Bank (with various parts classed as a Federal Migratory Bird Sanctuary, a National Wildlife Area, a Provincial Wildlife Management Area, and an Important Bird Area; www.bsc-eoc.org), numerous bird and mammal species use the area. For species like Dunlin, Western Sandpiper, Brant, American Wigeon, Northern Pintail, and Greater Scaup, these areas are major feeding and resting areas during the migration and over-wintering period. However, the entire area, by consequence of its location, is susceptible to water and beach contamination, shoreline development, and disturbance from hunting, fishing, and recreational and commercial boating.

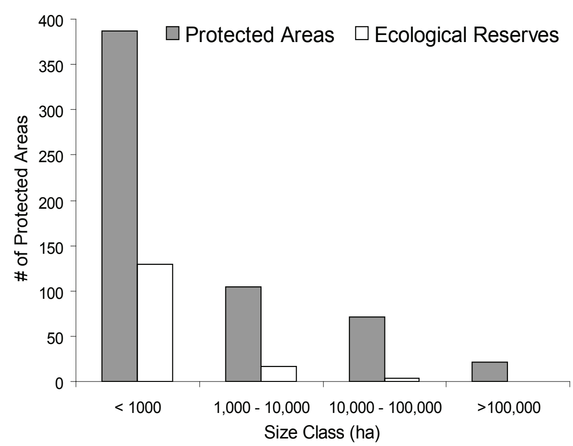

Figure 3. Frequency and size class distribution of ecological reserves and other protected areas (provincial parks, marine reserves, wilderness areas, and wildlife management areas) in British Columbia. Compiled from www.ecoreserves.bc.ca and wlapwww.gov.bc.ca/bcparks.

Conclusion

The need to monitor the effectiveness of protected areas has received considerable attention in the last 15 years (Saterson et al. (2004), but much remains to be learned from the approaches used to measure effectiveness. From a taxon standpoint, I investigated the potential for reserves to represent species and to facilitate population recovery. I also identified potential threats that species or populations may face, despite having occurred in areas with a long history of so-called "protection". Finally, I reviewed some of the protected areas in British Columbia and have attempted to relate their effectiveness within the context of this global overview.

Monitoring species is just one method of assessing how well current, or future, protected areas may be at maintaining biodiversity. Light is beginning to be shed on such issues of which taxa are most vulnerable, or most responsive, when attempting to relate the effects of management on specific taxa. For many programs, some are still in the early stages of determining which taxa are present (e.g., tropical areas), while in other areas (e.g., temperate North America), specific studies are addressing landscape and matrix (area outside the protected area) effects for species that occur exclusively or partially in protected areas.

Globally, species representation and protected area designation is not presently considered optimal from a vertebrate-only standpoint (Rodrigues et al. 2004). Representation is likely worse for marine and terrestrial invertebrates, plants, and fungi, especially considering that millions of species are potentially unknown. Inadequate representation appears mainly to be an issue of inappropriate reserve design and selection and a past failure to recognize species distribution patterns. An increasing number of studies are emphasizing optimal reserve selection, and various methodologies are being applied to determine this (e.g., Pressey et al. 2003; Westphal et al. 2003).

Protected area effectiveness will continue to be an increasingly important concern in the future, especially if they become "repositories for much of the world's biota" (Newmark 1995). For British Columbia, as well as for other areas in the world, prioritization must be given to endemic species and subspecies, and species or subspecies with significant world ranges or proportion of the world population. When designing reserve areas, consideration must also be given to the integrity, viability, and recovery of target species in the context of land-use and habitat conditions within, and adjacent to, the protected area.

Acknowledgements

I thank Dr. David Green (Simon Fraser University) for teaching the graduate Conservation Ecology class that led to the idea for writing this paper, and for providing constructive and insightful comments on an earlier draft. Thanks to Dennis A. Demarchi for peer-reviewing the final manuscript and providing valuable feedback.

Literature Cited

Brooks, T.M., G.A.B. da Fonesca, and A.S.L. Rodrigues. 2004. Protected areas and species. Conservation Biology 18:616-618.

Bunnell, F.L., R.W. Campbell, and K.A. Squires. 2004. Conservation priorities for peripheral species: the example of British Columbia. Canadian Journal of Forest Research 34:2240-2247.

Chape, S., S. Blyth, L. Fish, P. Fox, and M. Spalding. 2003. 2003 United Nations List of Protected Areas. IUCN – The World Conservation Union and UNEP World Conservation Monitoring Centre.

Currie, D.J. 1991. Energy and large-scale patterns of animal and plant species richness. The American Naturalist 137:27-49.

Ervin, J. 2003. Protected area assessments in perspective. BioScience 53:819-822.

Maliao, R.J., E.L. Webb., and K.R. Jensen. 2004. A survey of stock of the donkey's ear abalone, *Haliotis asinia* in the Sagay Marine Reserve, Philippines: evaluating effectiveness of marine protected area enforcement. Fisheries Research 66:343-353.

Moore, J.L., A. Balmford, T. Brooks, N.D. Burgess, L.A. Hansen, C. Rahbek, and P.H. Williams. 2003. Performance of sub-Saharan vertebrates as indicator groups for identifying priority areas for conservation. Conservation Biology 17:207-218.

Mosquera, I., I.M. Cote, S. Jennings, and J.D. Reynolds. 2004. Conservation benefits of marine reserves for fish populations. Animal Conservation 4:321-332.

Newmark, W.D. 1995. Extinction of mammal populations in western North American national parks. Conservation Biology 9:512-526.

Pressey, R.L., R.M. Cowling, and M. Rouget. 2003. Formulating conservation targets for biodiversity pattern and process in the Cape Floristic Region, South Africa. Biological Conservation 112:99-127.

Preston, J. 2004. Conservation priorities and peripheral species in the South Okanagan: considerations for a proposed national park. Wildlife Afield 1:46-53.

Rivard, D.H., J. Poitevin, D. Plasse, M. Carleton, and D.J. Currie. 2000. Changing species richness and composition in Canadian national parks. Conservation Biology 14:1099-1109.

Roberts, C.M., and RJ.P. Hawkins. 1999. Extinction risk in the sea. Trends in Ecology and Evolution 14:241-

246.

Rodrigues, A.S.L., S.J. Andelman, M.I. Bakarr, L. Boltani, T.M. Brooks, R.M. Cowling, L.D.C. Fishpool, G.A.B. de Fonesca, K.J. Gaston, M. Hoffmann, J.S. Long, P.A. Marquet, J.D. Pilgrim, R.L. Pressey, J. Schipper, W. Sechrest, S.N. Stuart, L.G. Underhill, R.W. Waller, M.E.J. Watts, and X. Yan. 2004. Effectiveness of the global protected area network in representing species diversity. Nature 428:640-643.

Saterson, K.A., N.L. Christensen, R.B. Jackson, R.A. Kramer, S.L. Pimm, M.D. Smith, J.B. Wiener. 2004. Disconnects in evaluating the relative effectiveness of conservation strategies. Conservation Biology 18:597-599.

Singh, S., and C. Volonte. 2001. Biodiversity program study. Global Environment Facility, Washington, D.C. (http://www.gefweb.org/Biodiv_Program_Study.pdf)

Turner, J.R.G., J.J. Lennon, and J.A. Lawrenson. 1988. British bird species distributions and the energy theory. Nature 335:539-541.

Westphal, M.I., M. Pickett, W.M. Getz, and H.P. Possingham. 2003. The use of stochastic dynamic programming in optimal landscape reconstruction for metapopulaions. Ecological Applications 13:543-555.

Woodroffe, R., and J.R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126-2128.

Wylie, J.L, and D.J. Currie. Species-energy theory and patterns of species richness: II. Predicting mammal species richness on isolated nature reserves. Biological Conservation 63:145-148.

About the Author

Michael is an M.Sc. candidate at Simon Fraser University studying the effects of variable retention forest practices on songbird communities near Campbell River on Vancouver Island.