ALTERNATIVE VIEWS OF RESERVE DESIGN FOR WILDLIFE MANAGERS

CHARLES VAN RIPER III, Department of Wildlife and Fisheries Biology and Cooperative Parks Studies Unit, University of California, Davis, CA 95616

JAMES F. QUINN, Division of Environmental Studies, University of California, Davis, CA 95616

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The most important environmental problem facing wildlife managers today is the long-term maintenance of native biotas. A large majority of North American wildlife species presently occur on state and federally managed lands, and this will be even more evident in years to come. A critical component of our future wildlife management goals will be to understand what are the best design strategies for wildlife sanctuaries, in order to assure the long-term maintenance of both species diversity and genetic variation. With the ever-increasing pressures exerted by the continually expanding human population, wildlife reserves will play an increasingly important role in species preservation.

The question of how best to design wildlife reserves in the face of continued consumptive human activity has been a central problem in American wildlife management policy since the early 20th century. The problem has recently become acute with the rapid clearing of western U.S. old-growth forests and further expansion of agriculture into marginal lands.

Historically, much of the emphasis in conservation has been on giant, flagship parks and reserves, intended to be large enough to encompass entire ecosystems. Recently, some conservation theorists have argued that even the flagship parks are too small, and have called for using scarce conservation capital mainly to establish or enlarge these few megaparks. While it is clear that effective management of some species (for example, grizzly bears) requires large tracts of land, it is not so clear that overall diversity is not better protected with a well-chosen collection of smaller reserves.

In a time of inadequate resources for conservation, wildlife managers must consider alternative approaches to preserve design, and not blindly rely on the adage that bigger is better. In order to assure that present and future wildlife reserves adequately fulfill the objectives that they were originally designed to accomplish, certain needs must be fulfilled. Throughout this paper we will be stressing the following criteria: (1) ensure that the objectives of the reserve are clearly defined and understood, (2) assure that adequate information exists on the habitat and associated organisms so that proper decisions can be made regarding reserve design and management, and (3) analyze the most effective allocation of scarce resources to achieve the conservation objectives.

We will try to weave these criteria throughout three case studies in this paper. The first section will deal with small-scale field experiments that we have been conducting at the University of California, Davis, on species diversity in experimental reserves of different sizes in a California annual grassland. The second will look into the present controversy of the ability of the National Park Service to maintain their terrestrial large mammal fauna. Our last section will present a scenario of reserve design for an endangered Hawaiian land bird.

ANNUAL CALIFORNIA GRASSLAND EXPERIMENT

In 1983 we established a 1.3-ha study area in an abandoned field outside Davis, California. The flora is typical of modern California annual grasslands. The study area is bordered on one side by riparian and the other agricultural habitat. Within the study area we established 42 fenced exclosures "reserves" of 3 sizes. The areas between are grazed intensively by sheep. The experimental reserves were placed randomly on a 9 X 7 grid with 32 reserves of 2 m^2, eight of 8 m^2 and two of 32 m^2. There were also half as many unfenced plots to test for grazing effects and the effectiveness of the sheep in isolating the exclosures. The design was such that each treatment has the same total area (64 m^2), but is fragmented into 2, 8, or 32 pieces. Our primary objectives were to look at the effects of fragmentation and isolation on species diversity, colonization, and extinction.

The results of this experiment are described in detail in Quinn and Robinson (1987) and Robinson and Quinn (1988). Over almost 5 years, species diversity of plants and arthropods has always been 20-60 percent greater in the most fragmented treatment (many small reserves) than in the least (a few large reserves). Moreover, there was no indication that stability, as measured by extinction or species turnover, decreased as a result of the degree of habitat fragmentation.

To be tractable, this experiment was done on a very small scale, with possibly unrepresentative groups of organisms. In an effort to determine if this was an anomalous situation, Quinn and Harrison (1988) analyzed species diversity data from over 30 previously published studies from the island biogeography literature. Data came from terrestrial habitat islands, such as mountaintops, forest remnants, and National Parks, as well as from oceanic islands. Taxa that they examined included birds, mammals, reptiles, amphibians, insects, and vascular plants. In all cases, similar patterns emerged.

When calculating the number of species from a number of small islands, compared to larger islands totaling the same area, the collections of smaller islands always had at least as many species as did the large islands. Other studies (Helliwell 1976, Higgs and Usher 1980, Jarvinen 1982, Simberloff and Abele 1982, Simberloff and Gotelli 1984) have come to similar conclusions.

Basic ecological studies of this kind suggest that wildlife managers face multiple alternative strategies for land acquisition to improve the effectiveness of reserve systems. If a principal objective of reserve establishment is to maximize biotic diversity, managers must take into account the possibility that numerous smaller reserves may fulfill this objective better than a single large reserve.

NATIONAL PARK SERVICE MAMMALS

A recent controversy has arisen over the ability of National Park Service units to preserve mammal species. This was highlighted in a book by A. Chase (1986), and culminated with the recent paper by Newmark (1987). This latter work is an example of where incomplete information can be misleading when suggesting a strategy for reserve design.

Newmark (1987) attempted to analyze large mammal extinctions in 12 park areas (mostly national parks) in western North America. He concluded that only some 60 percent of the historical mammal populations are still found in the parks, and that only the largest parks (tens of thousands of square kilometers) are large enough to prevent mammalian extinctions. He reports that the smaller parks were much more likely to lose species than were the larger parks. This study has received considerable public and congressional attention, and promises to greatly influence public policy.

In most cases, extinction can only be inferred from a lack of recent occurrences. If inventories are not made, or sightings are not recorded, it is easy to erroneously conclude that a rare or cryptic species has disappeared. Newmark inferred extinctions from a lack of records between 1973 and 1983. Re-examination of the available data suggests that most of these cases reflect faulty records rather than actual extinctions.

In an effort to substantiate or refute Newmark's conclusions, we queried each of the National Parks in his study, and attempted to reconstruct his data base (Quinn, van Riper, and Salwasser, in preparation). We contacted knowledgeable government and academic scientists and resource management personnel at each of the parks, research scientists that had recently worked in those parks, and those who had conducted surveys of the mammals. We also contacted U.S. Forest Service biologists in the National Forests immediately adjacent to the parks in question. Our findings were considerably different than what Newmark suggests. In the 12 U.S. parks,

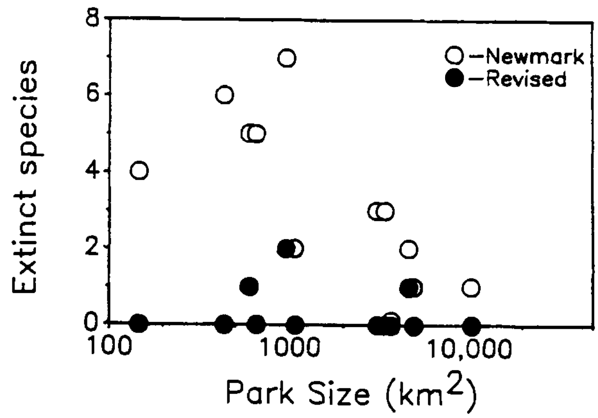

Fig. 1. The number of proposed natural mammal extinctions (subsequent to establishment) of 12 western U.S. National Parks, in relation to total park area. Open circles are from Newmark (1987), while closed circles represent the revised number of presumed extinctions following a more detailed inquiry into the presence or absence of those mammal species.

there is good evidence (sightings by park biologists, roadkills, etc.) for persistence of most of the of the 39 populations Newmark lists as extinct. In a few cases (for example, ringtails and ermine in Lassen Volcanic), the species is quite common in the park, though it may not have been formally recorded for a decade. Figure 1 shows our best estimates of the number of species that have actually disappeared from the parks (from natural causes, and after park establishment), compared with the number estimated by Newmark. If data from the immediately adjacent National Forests are added, there are only three candidates for natural extinction of large mammals from parks and their immediate environs - the wolf from Yellowstone, and the river otter from Mount Ranier and Sequoia-Kings Canyon. It is not clear that the otter was historically in either park, and the disappearance of the wolf from Yellowstone had considerable human help.

The only consistently extinct mammal species in National Park areas (regardless of size), are those that have been actively eliminated by humans, either by uncontrolled hunting (bison, caribou, elk, sheep) or by predator control (wolves, grizzly bears, jaguar).

If our data are correct, there is little or no indication that existing conservation lands are too small to protect the mammals currently found in the larger National Parks (the parks in Newmark's study range between roughly 100 and 20,000 km^2). They certainly provide no evidence that the smaller parks have drastically elevated natural extinction rates, and the smaller parks, which have been established in many more habitats, hold most of the system's overall diversity (Quinn 1989). This would suggest that the investment in smaller National Parks has been highly effective in preserving the mammalian biota. The fact that Newmark could reach opposite conclusions from inventories of the same parks points out the inadequacy the existing inventory information.

The role of multiple-use public lands has also been misunderstood. Newmark (1987) assumed that National Parks were essentially islands (or refuges) in a sea of inhospitable habitat. But the fact remains that most National Park areas are surrounded by federal or state lands (National Forests, State Parks, Bureau of Land Management areas). According to our data (Quinn, van Riper, and Salwasser, in preparation), only one mammal species found in the 12 U.S. National Parks is absent from adjacent National Forests (the reintroduced bighorn sheep in Zion National Park). Conversely, 11 species in the adjacent National Forests are not recorded from the parks, mostly because of habitat differences. National Parks need not be islands.

The conclusions that can be drawn from the above controversy underline the fact that proper decisions on reserve design can be drawn only after an adequate information base is established. The results of Newmark's efforts point up the fact that the National Park Service has inadequate resources base inventories even for popular species such as larger mammals. Wildlife managers must have current and accurate data on what plants and animals still exist in their present or proposed reserves. Moreover, they must have some idea of the numbers and productivity of those organisms. It is only after this information is obtained that managers can begin to make proper management decisions regarding appropriate reserve design.

RESERVE DESIGN IN HAWAII

We will now try to provide an example of a protocol that might be used in establishing a reserve design. In that this meeting is being held in Hawaii, and a field trip will be conducted into this habitat, perhaps you can weigh our suggestions and then come up with what strategies you would employ in designing this reserve.

The reserve that we are proposing is foran endangered Hawaiian honeycreeper, the palila (*Loxioides bailleui*). This bird is a member of the endemic Hawaiian honeycreepers and is currently classified as an endangered species (USFWS 1983). The palila is presently found only on Mauna Kea, Hawaii, and occupies approximately 10 percent of its historical range (van Riper et al. 1978, Fig. 2). The species was once found in the saddle area of Hualalai and Mauna Loa, but was extirpated from that habitat in the late 19th century (Munro 1944). Apparently, suitable habitat still exists in that area where palila no longer occur (Scott et al. 1986). The present population ranges between 1,500 and 6,000 individuals, is restricted to certain portions of Mauna Kea, and is intrinsically tied to mamane (*Sophora chrysophylla*) and naio (*Myoporum sandwicense*) habitats (Scott et al. 1984). The principal food of the palila is mamane pods, and the birds preferentially select mamane trees for nesting sites. The species has a high infertility (18 percent), small clutch size (n = 2), produces only one clutch per year, and as a result has a low productivity potential. The incubation and nestling periods are quite long, and nestlings foul the nest and surrounding area with pungent fecal material which can potentially attract predators. In addition, the effective breeding population is much reduced in that a number of nonbreeding individuals are present each year (van Riper 1980a). The species has also been found to be intolerant to high temperatures (Weathers and van Riper 1982) and to introduced diseases (van Riper and van Riper 1985, van Riper et al. 1986).

The objective of this reserve is to elevate the palila from an endangered status, and follows suggestions of the Palila Recovery Team (Berger et al. 1977). To ensure that objectives of this reserve are fulfilled, this species has to increase in numbers so as to achieve non-endangered status. Adequate information presently exists on many of the potential limiting factors regarding preservation of the palila. Initially, the species has to have adequate habitat in which to expand. There also has to be multiple reserves, in locations where temperature regimes are compatible with species survival and where disease is not a limiting factor.

In considering possible alternatives for the palila reserve design, a number of salient points surface. The present isolated population on Mauna Kea is a result of former habitat degradation by introduced feral and mouflon sheep (van Riper 1980b, Scowcroft and Giffin 1983). In order to ensure that adequate habitat exists for expansion of the population on Mauna Kea, lands on the high-elevation, eastern slope of the volcano should be procured, restored, and reserved for future palila expansion. To obtain lands at lower elevations would do little to benefit the species because of potential disease problems. However, to spread the risk of potential disease outbreaks, populations should be established in other habitats. A relocation program from the high density core area of Puu Laau (Scott et al. 1984), to the saddle area of Hualalai-Mauna Loa, would be insurance against a disease epizootic in the Mauna Kea population.

SUMMARY

Wildlife managers recognize that discerning the correct objectives of reserve design is extremely important. If the manager's goal is to maximize species diversity, perhaps a number of smaller reserves (of equal area to a single larger one) may frequently be a better

that reserve.

There are always a number of alternative reserve designs initially available to wildlife managers. With the continuing trend of decreasing dollars for land acquisition, it is imperative that all possible options are considered. In the case of the palila, a moderate increase in the size of the present reserve is a viable option. But to increase this single large reserve further into lower elevations would be ineffectual because of potential negative impacts due to physiological and disease constraints. Instead, the best strategy would be to expand slightly and to also create another reserve in formerly occupied habitat. This second reserve would spread the potential risk of a catastrophe (e.g.,disease) eliminating the population in a single reserve. In addition, the second reserve would provide habitat for other species and ultimately increase species diversity on the island.

It is important that wildlife biologists and managers look at and evaluate each situation individually. We can no longer afford to sit back and say that only bigger reserves are needed. This might not always be the best strategy to pursue. We need to demand an adequate resources base inventory of organisms in designated reserves prior to acquisition, so that wise decisions are made regarding reserve design. Finally, we must look at all possible alternatives for the best way to acquire and manage our limited and rapidly diminishing wildlife resources.

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