

Many and Large, Large and Small: Nature Reserves Debate Goes On

By Peter White

In the Fall 1985 issue of *Park Science* (Vol. 6, Number 1), James Quinn and his colleagues described their ongoing research on island biogeography and the design of nature reserves. They concluded that several smaller reserves may sometimes be preferable to one large reserve of the same total area. Quinn and his colleagues were careful to point out the constraints that apply to their conclusions. In this article I will begin by enlarging upon those constraints. I do not intend this as a criticism of Quinn and his colleagues' work — I found that work interesting and admirable. Rather, my purpose is to put the issues in a larger context. Indeed, an overall conservation strategy for North America, one that will meet the variety of necessary conservation goals, must use both relatively large and relatively small reserves in a complementary scheme. Such a scheme is evolving at the present time through the often unrelated efforts of several national, state, and private agencies. However, we might also consider whether a more coordinated strategy is desirable or practical.

My comments derive in part from joint research that I have carried out with Susan Bratton, Ron Miller, and Jonathan Ambrose at the University of Georgia under a grant from the Man and the Biosphere Consortium. Although I will be emphasizing constraints to Quinn's conclusions, our own work on the southern Appalachian flora also showed that, **where the goal is maximizing species number at the outset of preserve establishment and where economic limits are set**, many small reserves may sometimes contain more species than one large reserve of the same area. However, that conclusion is predicated on the assumption that the purpose at hand is only to maximize species number in the short-term (in our case the number of rare plants) and that the species now present are capable of persisting after fragmentation of the overall landscape. The same constraints that apply to the article by Quinn and his colleagues also apply to our analysis (White et al, 1983). Some of these constraints are critical and are my subject here.

I must first review some aspects of island biogeography as they apply to preserve design. The theory of island biogeography was developed from studies of oceanic islands and avifaunas. By contrast, nature reserves are almost always "carved" out of larger blocks of land (e.g., Great Smoky Mountains NP within the southern Appalachian mountains). The species-area relationship for true islands is almost always steeper than the species-area relationship for comparably sized blocks of land demarcated within an intact continental landscape. Thus, it was predicted that when parks were "carved" out of this larger block of land and became isolated and island-like, they would suffer "faunal collapse;" that is, they would lose species to some new (and lower) equilibrium value.

Some of the work reported by Quinn and his colleagues' work treats, in a sense, the pre-faunal col-

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lapse problem. The controls on their experiments (demarcated "samples" within large contiguous patches, plus measurements before and after patch creation) become critical. As parks are established, the island biogeographical literature suggested that they would lose species as a function of their isolation and size. Taking two similar sized patches within a larger intact area and isolating one by affecting the surrounding land and leaving the other surrounded by "natural" lands as before, is one way to test "faunal collapse."

By contrast, Quinn's and his colleagues' work and ours in the southern Appalachians ask somewhat different questions: how can we contain the greatest number of species as a function of area acquired? Given a fragmented landscape, which will contain more species, two one-half-sized reserves or one full-sized reserve? In other words, Quinn and his colleagues questions, as interesting as they are, are not the only relevant questions to ask. To put this another way: island biogeography suggests an equilibrium number of species will develop within a given area, all else being equal. Species-area curves at one point in time may not reflect equilibrium; there may be important processes at work which will change the shape of those curves over time.

The four constraints that I summarize from Quinn's article are: (1) maximizing diversity is just one kind of conservation goal (actually, the island biogeographical literature treats one component of diversity only — **richness**, the number of species contained within an area); (2) that small islands may come to be dominated by weedy species (i.e., that design strategies select for which species are present, as well as how many species are present); (3) that different groups of species (mammals vs. birds) and species with different behaviors (migratory animals vs. relatively sessile animals) show different responses to given design strategies (i.e., the characteristics of one group should not be extrapolated for all groups); and (4) that target species like the larger birds and mammals require larger areas for population maintenance than 99 percent of the other species present (this is critical since these species may be important in food chains and in influencing the population size of other species).

Summarizing these constraints, if the goal of a conservation effort is to preserve a representative piece of a particular wilderness landscape (e.g., for the central Rocky Mountains, the southern Appalachians, the Olympic Peninsula), the one cannot readily accept the conclusion of the article by Quinn and his colleagues. In this situation, species number is not the only concern, and which species are present is important. The last item alone might be used to argue that all preserves that have as their goal the protection of wilderness ecosystems and their component species ought to be large enough to contain a minimum viable population (>500 individuals) of all of their large mammals. Given the track record of some existing National Parks, this argues for quite large parks (>10⁵ — 10⁶ ha). Quinn's article makes it clear that these constraints are understood; I want only to emphasize that the goal of the National Park System on a continental scale probably is more in harmony with the purposes stated at the beginning of this paragraph than the purpose of preserving species number alone.

Beyond the four constraints listed above, there are several additional concerns. The first two constraints

below have to do with the processes responsible for the presence or absence of species within a given area when a preserve is "designed." These constraints suggest that area itself must be measured carefully — that drawing a line around populations at one point in time does not guarantee that you have contained all the necessary processes to maintain those populations in perpetuity.

(1) **Ecosystems are patchy in time and space.** As Pickett and Thompson (1978) discussed, natural disturbances (e.g., fire) may create landscapes which do not contain all seral stages — the preserve must be expanded to include the relevant area or will be vulnerable to particular natural events. Romme and Knight (1982) recently showed that the patch size of natural fire in Yellowstone National Park was large relative to a single watershed and that the Park itself (among the largest in the US) was barely large enough for a putative fire controlled equilibrium mosaic. In terms of static patchiness, it would be wrong to assume that the total area of a reserve is available to all species — there may be critically small habitat patches within even large reserves.

(2) **Species number within even large reserves may depend in part on lands beyond the reserve boundaries.** Most of our National Parks are contiguous with National Forest lands. Animals, even in large reserves, move in and out of the reserve. In other words, current parks may not be truly ecologically isolated; the species present within these parks in the short-term may not persist in the longer term if the reserve becomes island-like. They would thus require active management (reintroduction, prevention of extinction) — and I argue that the smaller the preserve, the greater the management effort necessary.

A third constraint has to do with threats to nature reserves:

(3) **Threats affect even the largest reserves.** This was Kushlan's (1979) point in a discussion of Everglades NP — that is a large park that nonetheless lost species due to water regime changes. Small reserves will depend on intensive management, whereas large reserves have a hope (albeit a faint one in the days of the spread of pollutants) of being self-maintaining wilderness.

My final constraint has to do with the definition of "large" and "small" sizes for reserves. We tend to debate strategies of "large" and "small" reserves without specifying spatial scale for particular circumstances.

(4) **The results of the article lack an absolute spatial dimension.** For example, 10 individual, non-contiguous, parks each one-tenth the size of Yellowstone might contain more species than Yellowstone itself (let us accept this for the sake of argument). But then 10 non-contiguous parks each one-tenth the size of these "smaller" parks (we are down now to parks one-hundredth the size of Yellowstone) would probably also contain more species than a single one-tenth-of-Yellowstone-park. Why? I believe these kinds of results are an artifact of how life's diversity is generally spread over the landscape. Contiguous areas are usually more alike in species content than

non-contiguous areas.

To explain this last point, let us go to a very broad scale. If the goal of a particular conservation effort was to preserve the mammal fauna of the North American continent, then 10 reserves each the size of Yellowstone NP and spread out over the continent might be better (have more species) than one reserve equal to 10 times the area of Yellowstone and centered over that National Park — spread out over the continent, the parks would include more geographic areas, environments, and habitats. Thus, many "small" parks is better than one "large" park of the same total size. But in this case our "small" parks are indeed quite large. And the problem doesn't stop there — a system of 10 reserves each 10 times the size of Yellowstone would be better than one reserve 100 times the size of Yellowstone.

I doubt the chain of relativity can be broken for any particular landscape. That is, I believe the conclusions of Quinn and his colleagues cannot be used to specify a particular preserve size or subdivision strategy, unless some limitation is first imposed. They can be used if a conservation goal is first stated (e.g., preserving the flora of a county in California, or of the whole state, or of the nation) and if economic limits are imposed (e.g., the amount of land that can be acquired is pre-set). Under these circumstances, one could evaluate the one-large versus several-smaller preserve strategies. If the goal and economic resources are varied, then the optimum strategy varies. The National Park Service's goals, as I understand them, tend to be whole-system and continental in scope. Before carrying out design based on subdivision (because of limited financial resources), it might be desirable to find the political will to accomplish a larger conservation purpose (e.g., instead of creating 10, one-tenth-sized, reserves for a total size of 10⁴ ha, find the resources to create 10 full-sized reserves at a total size of 10⁵ ha).

To list some simple lessons from our existing large National Parks: Yellowstone is barely large enough for a predictable outplay of its fire regime and too small for its large grazers and predators to be influenced by Park Service policy only. Everglades, while the largest National Park in the East is too small to contain its own hydrologic regime and has seen declining populations as a result. Great Smoky Mountains NP has lost its large predators and is influenced by the spread of exotic species, flooding by a man-made reservoir, and air pollutants from beyond park borders.

The island biogeographical literature usually gives us two preserve variables (size and number) and thus four choices: few-small, few-large, many-small, and many-large. The first is not discussed since it represents biological folly. The best strategy from a strict conservationist's view point (many and large parks) is omitted from most articles such as mine and that of Quinn and his colleagues only out of deference to political reality. Although the literature has tended to produce polarized debate over the remaining choices (many-small vs. few-large), could it be that both can be important?

An ideal conservation strategy at the continental scale might include many large parks set aside for the goal of maintaining wilderness ecosystems. Such parks would be large enough to support self-sustaining populations of all large mammals and birds (I single these taxa out because they tend to have the largest home ranges) and would be large enough to contain the natural dynamic mosaics of seral states

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caused by the outplay of natural disturbances like fire. Let us call this park goal #1. Such a goal is national in scope and such preserves would be $>10^4$ ha in extent. There should be a minimum of 5 of these "goal #1 parks" in each biogeographic province.

Next, there should be a system of smaller areas (10^1 to 10^3 ha) that have the purpose of protecting additional species within the biogeographic provinces and valuable natural resources (including old-growth forests, geologic features, unusual habitat types). Such private groups as the Nature Conservancy are already working along these lines. Thus, the ideal conservation strategy would always include many reserves; relatively large and relatively small reserves might both have a function in this strategy.

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