increased catecholamine metabolism) in the central nervous system (10), the hippocampus could be one of the sites of this restoration process.

The electrical activity of the hippocampus is unusual. While the rest of the brain shows a desynchronized EEG pattern during attention, learning, and paradoxical sleep, the hippocampus displays a synchronized electrical activity of four to seven cycles per second (theta rhythm) (11). It is suggested that the hippocampus, through synchronizing influences on the neocortical and subcortical structures, counteracts the effects exerted by the ascending reticular-activating system, and that the functional interplay of the hippocampus and reticular system seems to be of importance with regard to the rhythm of sleep and wakefulness (12). Spontaneous activity of the hippocampal pyramidal cells in cats with permanently implanted electrodes sharply decreased in SWS (13), a phenomenon observed in other brain areas (14). It may be that the electrical activity of specific brain structures during SWS is keyed to local chemical processes. Our data regarding the chemical changes in the hippocampus during SWS indicate that the 5-HT and DA systems become activated at this time. This is of interest because recent hypotheses propose an increased activity in the 5-HT system of the raphe nuclei during SWS and an increased activity in the catecholamine system of the nucleus locus coeruleus during paradoxical sleep (15). Because of the reciprocal connection between limbic-forebrain structures (including the hippocampus) and the raphe nuclei, the latter are potentially modulated by limbic-forebrain mechanisms (15). When 80 to 90 percent of the raphe system is destroyed, animals enter a state of permanent arousal that lasts 3 to 4 days; SWS returns partially within a 4-week period (16), and near normal sleep profile (16) appears by day 30. This indicates that other brain sites functionally compensate for the loss of 5-HT neurons in the raphe. Furthermore, since hippocampectomy was found to reduce significantly both SWS and paradoxical sleep, the hippocampus has been implicated in the facilitation of both SWS and paradoxical sleep (17). Although hibernation differs from normal sleep in many respects (18), it has been reported that when animals are entering hibernation, the concentration of 5-HT increases in the hippocampus several times more than it does in other brain areas (19). Also, when 5-hydroxytryptophan, an immediate precursor of 5-HT, is administered to rats, the highest concentration of 5-HT is found in the hippocampus (20); when administered to rabbits, 5-hydroxytryptophan results in the most marked rate of increase in 5-HT being found in the hippocampus (21). All these findings point to the importance of a serotonergic mechanism in the hippocampus, and possibly a different role of this area in SWS. The specific increases in the metabolism of 5-HT and the concentration of DA in the hippocampus during SWS indicate that the hippocampus functions as a subsidiary sleep structure to the raphe system and the nucleus locus coeruleus in the brainstem. We also suggest that the obtained decrease in DA metabolism in the striatum and thalamus during SWS may be related to the sleep-generating mechanisms.

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References and Notes

4. Since dura mater contains partner receptors, removal of the dura prior to the experimental procedure was an important part of the technique. It enabled painless cutting of the brain tissue and ablation of the left hemisphere with the least disturbance to the animal.
5. The striatum-thalamus included the putamen, globus pallidus, tail of caudate nucleus, claustrum, and thalamus.
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Island Biogeography and Conservation:
Strategy and Limitations

As human destruction of remaining natural habitats accelerates, biologists have felt intuitively that most existing wildlife refuges are too small to avert extinctions of numerous species. However, because there has been no firm basis for even approximately predicting extinctions in refuges, biologists have had difficulty convincing government planners faced with conflicting land-use priorities to increase the size of wildlife refuges, or even to extend the number of refuges.

Simberloff and Abele (7) argue that these applications of biogeographic theory to conservation practice are premature and are based on insufficiently validated theory and possibly also on idiosyncratic results. These authors show that, given certain assumptions, several small refuges may contain more species than a single large refuge of equivalent area. Their reasoning from their assumptions is correct but minimizes or ignores much more important
conservation problems. Because those indifferent to biological conservation may seize on Simberloff and Abele's report as scientific evidence that large refuges are not needed, it is important to understand the flaws in their reasoning.

Human activities threaten some species and habitats more than others. Humans are preferentially destroying some habitats (for example, primary tropical rain forest) and creating others (for example, roadsides and pastures). In addition, species of high dispersal ability and high reproductive potential, living in successful habitats, can survive human-related environmental changes much better than can sedentary species of low reproductive potential that are confined to more mature habitats. Thus, conservation strategy should not treat all species as equal but must focus on species and habitats threatened by human activities. What are the area requirements and dispersal abilities of these extinction-prone species?

First, consider area requirements of species that can disperse among islands or habitat patches. Despite their ability to disperse, such species are often found to be confined to islands or patches much larger than the territory size of a single pair [see (5) for summary]. For example, minimum area requirements of populations of those southwest Pacific land bird species that can colonize islands overwater range up to thousands of square kilometers for species whose territories are measured in hectares (3). Iguanid lizard populations of the Bahamas are confined to islands large enough to support about 100 lizards (8). Similar examples of minimum area requirements have been reported for North American ants, North American birds, and British birds (9). These requirements result from several factors (3, 5). (i) Some habitats exist only on larger islands or patches; (ii) species that seasonally or spatially patchy food supplies must integrate resources over large areas; (iii) species that live at low densities, and hence often become extinct on small islands but rarely recolonize, have low probability of occurrence at equilibrium except on large islands; and (iv) “hot spots” of locally high resource production may be important hedges against extinction but may constitute only a small fraction of breeding territories.

For species capable of dispersal between “islands,” extinction of a population in one refuge may possibly be reversed by colonization from another refuge. The island dilemma is posed in more acute form by species that are unable or unwilling to disperse across water or alien habitat. Such species include not only flightless organisms but also birds that are strong fliers. For example, many Californian bird species have never been observed on islands or desert oases 20 km from their breeding sites (10); 302 of the 513 breeding land bird species of New Guinea have never been observed on a single oceanic island, not even large islands 8 km from New Guinea (4); and 55 of the 127 breeding land bird species of New Britain never appeared, even as vagrants, on an 8-km2 island 6 km offshore during several decades' residence by Meyer, a keen observer (3). Since there are no immigrations to reverse extinction on an island or habitat patch for such species, minimum area requirements are considerably larger than for species capable of dispersal. Thus, New Guinea is surrounded by many “land-bridge islands” that formed part of New Guinea during low sea level of Pleistocene times up to 10,000 years ago. At the present time, 32 of the 134 New Guinea lowland bird species that do not colonize overwater have disappeared from all land-bridge islands, even ones as large as 8000 km². These extinction-prone species with large area requirements include some of the most distinctive New Guinea bird species, such as the vulturine parrot Psittichus fulgidus, harpy eagle Harpopsis novaeguineae, and shovel-billed kingfisher Cbytoceyy rex (4). Yet few proposed refuges exceed 8000 km² in area.

Similar patterns of differential post-Pleistocene extinction on real land-bridge islands in the ocean, or on virtual ones in seas of alien habitat, have been described for west Australian macropod marsupials, southeast Australian marsupials and rodents, North American montane mammals, neotropical birds, Bismarck Archipelago birds, Solomon Island birds, and Australian lizards (2-5, 11). In all of these studies, most bird and mammal species incapable of interisland dispersal were found to disappear from all islands smaller than a few hundred square kilometers, and some species disappeared even from all islands of many thousand square kilometers. While these patterns are the product of population fluctuations for about 10,000 years, studies in this century on many New Zealand forest reserves (6) and on Panama's Barro Colorado reserve (2) show that many extinctions occur within a few decades, especially in smaller refuges.

As a result of this differential susceptibility of species to extinction in isolated populations, small refuges or islands mainly lose the sedentary species of mature habitats that are most threatened by human activities, and retain the rapidly dispersing successional and edge species that need no protection. For instance, small forest reserves in New Zealand gradually lose all bird populations belonging to old endemic families and retain a standard quota of birds that are also widespread in suburban gardens, mostly species that recently immigrated or were introduced by Europeans to New Zealand (6).

Simberloff and Abele (7) suggest several reasons that they believe argue for small refuges under some circumstances.

1) Their main argument is that, depending on species pool size and relative areas of refuges, several small refuges sometimes contain somewhat more species than an equivalent area in one large refuge. This argument is scarcely relevant, since species must be weighted, not just counted; the question is not which refuge system contains more total species, but which contains more species that would be doomed to extinction in the absence of refuges. A refuge system that contained many species like starling and house rat while losing only a few species like ivory-billed woodpecker and timber wolf would be a disaster.

2) "For 'fugitive species' adding up to a small fraction of a regional biota a single large refuge could be exactly the wrong strategy" (7). This argument is also usually irrelevant, since fugitive species of high dispersal ability will often survive well in the absence of any refuges.

3) Catastrophes like fire or disease could affect populations in the whole of a large refuge but might not reach some of a network of small refuges. This argument is valid.

4) Implicit in a comment by Simberloff and Abele (their sentence "More realistically, we would hypothesize . . . ") is the recognition that each small refuge might save a different member of a set of mutually exclusive competitors, of which one would come to exclude the others from a single large reserve. This argument is also valid.

Against the two valid arguments for multiple refuges must be set the clear message of the island dilemma: different species have different minimum area requirements, while cases of maximum area limits are extremely rare, and the species most in need of refuges are doomed in a system of small refuges. The extinctions in the New Zealand forest reserves and on Barro Colorado warn us how rapidly the ecosystems of undersized reserves can collapse to an inevitable final solution. If the best solution of a system of multiple large refuges cannot
be achieved, the best compromise would be one refuge as large as possible plus some smaller refuges. This recommendation is not based on idiosyncratic taxa but on a variety of taxa on at least four continents. Nor is this recommendation premature, in view of the clear message and the rapid pace of human destruction of natural habitats. In the absence of input from biologists, developers may often prefer small refuges as being easier to create and as leaving more land for development goals of obvious political significance. Biologists should familiarize themselves with the island dilemma so that their arguments for large refuges will be explicit and persuasive.

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Certain interpretations in the report by Simberloff and Abele (1), if accepted uncritically, could be detrimental to efforts to protect endangered wildlife.

Following a now well-established practice, Simberloff and Abele use results from island biogeography to draw inferences about the efficacy of isolated parks and refuges as reservoirs of natural diversity. However, some of their conclusions are contrary to those espoused by others who have considered the same problem (2-4).

Simberloff and Abele consider an experiment in which very small (<0.05 km$^2$), isolated coves of mangroves were dissected into several lesser units separated by channels wide enough to reduce the dispersal of some of the arthropod species present. After an equilibration period of 3 years, a census was again made of the "archipelago" for its arthropod fauna, with the result that the collection of separate islets contained a few more species (81 as compared to 77) than did the original intact cope. From this they conclude that "the more (and smaller) refuges posited as an alternative to a single large one, the more likely is the archipelago of small refuges to contain more species."

A key feature of their experiment was the presence nearby of large continuous stands of mangroves containing a rich "source" fauna of hundreds of species of arthropods, many of which were capable of invading tiny outlying islets. Indeed, in discussing the experiment, they recognize that "possibly the increased extinction rates on the individual islands in this mangrove archipelago are more than compensated for by the presence of the other islands as nearby sources generating high propagule invasion rates." In contrast, those of us who have argued the essentiality of large preserves have imagined quite a different scenario, one in which most of the landscape has been preempted by agricultural or other human uses, and in which scattered parishes remain as the only redeaths for species that are unable to adapt to degraded habitats. The islands considered by Simberloff and Abele were at equilibrium, meaning that extinctions were in balance with recurrent immigrations from a rich external source. However, the dynamics of equilibrium systems are simply not germane to the problem of isolated parks set in an intensively exploited landscape; rather, the appropriate context is that of landbridge islands in which the source has been removed and only islands remain. Under these circumstances, logic calls for a strategy of minimizing extinctions, and this, I contend, is best accomplished with large preserves. As I shall explain below, there are circumstances in which large preserves are neither necessary nor appropriate, but these are special cases directed toward particular species, rather than toward whole ecosystems.

If it is agreed that the primary objective of a rational conservation policy should be to preserve viable populations of as many as possible of the species that inhabited the pristine landscape, then at least some large reserves are a necessity. This is immediately evident from the fact that species at the top of the trophic ladder (such as wolves, bears, eagles, and mountain lions) require extensive foraging ranges. Population densities of such species are low, typically on the order of one individual per 10 km$^2$. To protect representative samples of complete ecosystems, areas of hundreds or thousands of square kilometers are essential.

An optimal system of preserves should be designed to minimize extinctions, a matter that Simberloff and Abele pass over lightly. Much of our knowledge of extinction rates comes from the study of land-bridge islands, islands that were cut off from the adjacent mainland by rising water levels at some known time in the past (frequently the end of the Pleistocene). Kinetic analysis begins with the assumption that land-bridge islands initially contained a species complement equal to that of an equivalent-sized segment of mainland. When dispersal is shut off or severely restricted by the interposition of a water barrier, the high-diversity ecosystem of the newly created island begins to "relax," and eventually converges toward the low-diversity condition of a strictly oceanic island of equivalent size, climate, and remote-ness. Several studies of land-bridge islands have been completed, and the results are gratifyingly concordant (3-5). The following conclusions appear to be well substantiated.

1) Species loss is area dependent. An island of 250 km$^2$ is estimated to lose about 4 percent of its resident bird species during the first century, while one of 5000 km$^2$ loses only 0.5 percent (6).

2) Extinctions proceed rapidly at first as the most vulnerable species drop out, and then at a diminishing pace as the community approaches equilibrium.

3) Among the first species to expire are those on the highest rungs of the trophic ladder, and the largest members of feeding guilds. The implications of this are uncertain, because the effects of top predators, or even herbivores, on the interactions of species in the lower trophic levels of terrestrial ecosystems are poorly understood. In some aquatic ecosystems, however, it is known that the removal of "keystone" predators can lead to dramatically altered, usually less diverse communities (6).

4) Where it has been possible to examine replicated groups of land-bridge islands, the evidence suggests that the order of extinctions is highly consistent. One can infer from this that the individual units of a scattered park system would lose very similar sets of species.

5) As relaxation goes to completion, the character of land-bridge island avian communities is gradually transformed from one typical of the dominant vegeta-
tion (such as primary rain forest) to one
typical of successional vegetation (even
though the quality of the habitat appar­
ently remains unaltered). In other words,
the end point of relaxation is a commu­
nity composed largely or entirely of wide­
spread "weedy" species which are of
negligible interest to conservationists.

In conclusion, I can affirm that exten­
sive areas are needed to preserve exam­
ple models of the species-area relation­
ship (2). According to such models, the equilibrial species num­
ber on a large island is higher than the
number on an ecologically similar but
smaller island, because the immigration
rate of new species is lower and the
extinction rate of resident species is high­
er on smaller islands. In addition, be­
cause immigration rates decrease with
distance, classical models also predict
that more species should be maintained
on islands close to continental source
areas. Simberloff and Abele accept these
predictions but present computations
that show that a given refuge area may
support more species if it consists of a
number of smaller units. To obtain this
result, they propose a model in which all
of the species in the pool have equal
dispersal and survival abilities or in
which strong interactions between spe­
cies make it likely that different sets of
species will survive on different islands,
or both. However, there is no evidence
that such extreme conditions are in fact
approached in complex communities (4).

As for different reptiles, birds, and
mammals require different minimum
insular areas for long-term survival (5);
most prudent preserve­
nment, but had been extirpated by the
North. However, there is no evidence
that such extreme conditions are in fact
approached in complex communities (4).

For example, different reptiles, birds,
and mammals require different minimum
insular areas for long-term survival (5);
families of birds differ in their species­
area relationships (6); extinction rates on
land-bridge islands differ among taxa (7);
forest-interior bird species, especially
those nesting on or near the ground, tend
to disappear more rapidly from small for­
ested areas in both tropical (8) and tem­
perate (9) latitudes; and even mangrove
arthropods differ in their ability to estab­
lish and maintain populations on small
islands (10). The diversity of species sen­
sitive to effects of area and isolation
demonstrates that, contrary to the sug­
gestion of Simberloff and Abele, such
sensitivity is not a taxal idiomsycrasy.

The inevitable consequence of such di­
versity in the context of the proposed
series of small preserves would be the
preferential extinction of the more sensi­
tive species and the emergence on each
island of a species assemblage whose
members can utilize disturbed habitats
and therefore are destined to survive
even in the absence of preserves.

A second inadequacy of individual
small faunal preserves, or series of such
preserves, is their failure to provide a
reasonable facsimile of the entire func­
tioning ecological community they are
intended to represent. In fact, Simber­
lof and Abele agree with Sullivan and Shaf­
fer (11) that the preservation of entire
communities rather than single endan­
ergged species is a highly desirable goal.
If a functioning community is to be
preserved, it must be acknowledged that
some species, particularly large ones and
those at higher trophic levels, require
extensive areas of continuous habitat for
survival. For example, no one would
propose that an entire mangrove commu­
nity, including vertebrates and larger
invertebrates, could be preserved in re­
serves the size of the intact islands (0.02
to 0.05 ha) studied by Simberloff and
Abele (1), much less in the tinier archi­
pelagos created, even if many islets were
involved.

Human impact is often a serious practi­
cal problem in natural areas because rec­
reational activity is usually programmed
into the reserve from the outset, or if not
programmed, is difficult to prevent. The
effects of such activity can be severe
even in gigantic national parks (12). In
small reserves, human influences can be
disastrous.

Island area, isolation, and human dis­
turbance may interact in complex fash­
ion. Although Simberloff and Abele refer
to a critique by Lynch and Johnson (13)
of reported high avian turnover rates on
islands, one of the main points of the
critique was that many insular extinc­
tions and colonizations have been re­
lated to human disturbance. However,
the perturbations that result from habitat
alteration and destruction, introduction
of nonnative species, use of pesticides,
or other stresses are becoming increas­
ingly important determinants of species
composition and turnover. These influ­
ences will intensify in the future and will
have greatest effect on small preserves.
Therefore, the prudent preserva­
tion strategies are those that insulate sen­
sitive species from the effects of human
disturbance by setting aside large contin­
uous natural areas.

Classical theory (3) predicts high turn­
over rates on small isolated islands. To
emphasize the reality of such turnover
on mainland "habitat islands" we cite
results of KendiIegh's annual censuses of
breeding birds (14, 15) for Trelase Woods,
a 22-ha deciduous forest pre­
save in Illinois that is surrounded by
agricultural land. Several patterns are
evident. (i) Annual turnover, computed
by the method of Diamond (16), was high
(mean = 13.6 percent; range = 5.3 to
27.3 percent for the years 1934-1975). Of
62 breeding bird species, only nine (17)
have been present in each of the 48 cen­
suses since 1927. (ii) Three forest interior
specialists characteristic of the Eastern
deciduous forest (14) have not bred in
the woods during the census period; six
others (18) have bred only sporadically
for a year or two at a time. It is reason­
able to assume that some or all of these
species nested regularly (19) in the pri­
mordial forest prior to European settle­
ment, but had been extirpated by the
time of the first census in the relic wood­
land. (iii) Ecologically generalized
("weedy") species, many of them per­

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Simberloff and Abele (1) have ques­
tioned recent recommendations (2) that
faunal preservation can best be accom­
plished by establishing single large re­
erves. Instead, they conclude that theo­
retical considerations could in certain
circumstances support the sequestering
of a series of smaller reserves, and they
present experimental evidence in sup­
port of this view. However, their propo­
sition depends on biologically unrealistic
assumptions and should not be applied to
any practical problem of conservation
without explicit proof that the assump­
tions are true.

Simberloff and Abele address them­
215995 themselves mainly to predictions arising from
classic mathematical models of the spe­
cies-area relationship (3). According to
such models, the equilibrial species num­
be
manent residents or short distance mi-
grants, now dominate the Trelease Woods avifauna. (iv) Between 1934 and 1953, the mean species richness of the avifauna in Trelease Woods was 23.3 (standard deviation = 4.9). By about 1953 the third most abundant tree, American elm (Ulmus americana), had begun to die from Dutch Elm disease. The years 1954 through 1975 then witnessed a highly significant (P < .01) increase in avian species richness to an average of 32.5 (standard deviation = 2.8), but predictably (26), the birds that profited were forest-edge species. Thus, an additional inadequacy of small preserves is their sensitivity to destabilization.

Many of the edge species that colonized the interior of Trelease Woods in spectacular fashion during its destabilization also colonize the edges of artificial swaths cut through forest (21). In such cases, the overall avian species richness in an area is increased, but only at the expense of forest-interior species. We therefore hope that the experimental design (4) of Simberloff and Abele, in which such ecotonal effects may have been absent, will not be used to justify disastrous fragmentation of existing forest by roads, pipelines, or similar projects. Our objections to the creation of long strips of edge within a single preserve apply even more strongly to series of small forest preserves. In areas where forest is reduced to isolated woodlots, avian brood parasites, egg predators, and nonnative nest-hole competitors are usually abundant (22) in the surrounding agricultural and urban environments and often invade small tracts. Even acting singly, such species can exert intolerable pressure on other species (23), and their combined impact may be a major force in the avifaunal changes that succeed forest fragmentation.

We now wish to apply our general reasoning to preservation of the Eastern deciduous forest, a system with which we have considerable firsthand experience. Simberloff and Abele cite Terborgh's statement (2) that reduction and fragmentation of the forests of Eastern North America caused the extinction of, at most, two bird species. Although it is true that few North American birds have become extinct on a continental scale within historic times, we contend that optimism about the avifauna of the Eastern forest is warranted only as long as extensive areas of homogeneous forest remain standing. In fact, Terborgh pointed out correctly (2) that important factors in avian species survival were (i) the ability of most forest birds to utilize middle successional second growth and (ii) the retention of a total forested area, which, even at its lowest ebb, was never much below half of the original area. Today the Eastern forest is an archipelago of second growth woodland fragments that vary greatly in size, and it is therefore possible to determine whether subsets of these fragments are in fact acting as preserves on a contemporary basis. Breeding bird censuses and surveys in Eastern North America (24, 25) show that avifaunal composition of forest fragments depends on their size. In extensive forest tracts, up to 92 percent of the breeding individuals are neotropical migrants (26). However, many neotropical migrant species disappear from small isolated forest tracts such as Trelease Woods, and the avifauna of such tracts tend to be dominated by species that are either permanent residents or short distance migrants (9, 25). Extensive censuses and survey work (27) in central Maryland shows that small (less than 22 ha) tracts have a depleted avifaunal composition also characteristic of suburban and parks (9), but that deterioration has not occurred in fragments of similar size and vegetational composition adjacent to extensive forest (28). Also, countywide mapping projects (29) have demonstrated that some neotropical migrants apparently no longer breed in agricultural regions where forest fragmentation is most severe. Loss or reduction in breeding densities of neotropical migrant individuals has occurred in a relatively undisturbed mesic forest fragment that is hundreds of years old (20) and in large urban parks of second growth forest (27, 30). For example, in a forest plot within Rock Creek Park in the District of Columbia, the percentage of migrant breeders declined from 87 percent in 1948 to 35 percent in 1974 (30). The rapidity of decay of the original avifauna in urban parks, in contrast to slower decays (20) in relatively undisturbed forest fragments and lack of perceptible decay in nearby extensive homogeneous forest (28), implicates human perturbation as an important factor contributing to the deterioration. Thus the available data for the Eastern forest, from demonstrating that large faunal preserves are unnecessary, describe a troubled system in which local and regional extinctions of forest interior specialists are commonplace and in which large series of existing small, isolated forest areas have failed to preserve, even in contemporary time, many of the small avian species that once dominated the forest.

The final argument against fragmentation of our rapidly disappearing large areas of relatively undisturbed habitat is the unhappy fact that the process is, for all practical purposes, irreversible. Simberloff and Abele's concern about the "cost and irreversibility of large-scale conservation programs" (1) ignores the fact that it is much easier to convert a natural area into a housing development than vice versa. Therefore, the most prudent strategy is to maximize reserve size. If, as Simberloff and Abele propose, an alternate strategy proves more useful in specific instances we anticipate no shortage of economic interests willing to fragment the preserves at a later date.

We feel some responsibility to suggest orders of size that are relevant to the design of preserves. Optimal size for preserves varies with geography and the kinds of communities involved, but the history of Barro Colorado Island in the Panama Canal Zone is a stern reminder of the irreversible losses that might occur if the size of a preserve is inadequate. In this instance (8, 31) an area of nearly 1500 ha was insufficient to retain the characteristic avifauna of the larger tropical forest from which the island was separated by canal construction in 1914. Our analysis of the Trelease Woods data shows that 22 ha is hopelessly small, even for preservation of small forest-interior birds. We agree with the principle suggested by Sullivan and Shafter (17) that primary reserves should be of sufficient size to support stable populations of large mammals, and with Terborgh in his estimate that thousands of square kilometers may be required to reduce extinction rates to acceptable levels. If such sizes are involved, there seems to be no need for controversy about the optimal size of forest preserves, since we are unaware of any plans or opportunities to sequester areas that would be inappropriately large.

An acknowledgment of the need for large preserves should not be misconstrued as an argument against smaller ones. Certainly, small reserves are better than none and can accomplish such purposes as (i) preservation of taxa that can survive in small areas, (ii) preservation of unique microhabitats, (iii) provision of "stepping stones" between larger reserves, and (iv) provision of local educational and recreational benefits. We do, therefore, encourage the sequestering of small reserves whenever the establishment of a large reserve is not possible.

In summary, we urge that the size of ecological preserves be maximized because (i) large areas have high immigration rates and low extinction rates; (ii) some taxa require very large areas for survival; (iii) preservation of entire ecological communities, with all trophic levels represented, requires large areas; (iv) large preserves are better buffered.
against human perturbation and natural disaster; (v) large areas are necessary to minimize the pressures of predation, parasitism, and competition exerted by species abundant in the disturbed areas surrounding the reserves; (vi) failures of small reserves, originally considered to be adequate, have been amply documented; and (vii) the irreversibility of fragmentation demands a conservative preservation strategy.

Simberloff and Abele have performed a useful service by focusing attention on the potential pitfalls of an oversimplified model. We contend, however, that existing theory corroborated by empirical data is sufficient to validate the general conclusion that refuges should contain large contiguous areas as possible.

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4. Simberloff and Abele report that one of two artificial archipelagos constructed by channeling a small mangrove forest contained marginally more species of arboresal arthropods than the single island from which it had been created (81 species compared to 77 species), but this small difference is not convincing.


