Consequences and Costs of Conservation Corridors

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Abstract: *There are few controlled data with which to assess the conservation role of corridors connecting refuges. If corridors were used sufficiently, they could alleviate threats from inbreeding depression and demographic stochasticity. For species that require more resources than are available in single refuges, a network of refuges connected by corridors may allow persistence. Finally, a corridor, such as a riparian forest, may constitute an important habitat in its own right. A dearth of information on the degree to which different species use corridors makes it difficult to tell which of these potential advantages will be realized in any particular case. Some experimental field studies suggest that certain species will use corridors, although lack of controls usually precludes a firm statement that corridors will prevent extinction.*

Corridors may have costs as well as potential benefits. They may transmit contagious diseases, fires, and other catastrophes, and they may increase exposure of animals to predators, domestic animals, and poachers. Corridors also bear economic costs. For example, a bridge that would maintain a riparian corridor costs about 13 times as much per lane-mile as would a road that would sever the corridor. Also, per-unit-area management costs may be larger for corridors than for refuges. It may be cheaper to manage some species by moving individuals between refuges rather than by buying and maintaining corridors.

Each case must be judged on its own merits because species–environment interactions differ. As an example, we used the case of the Florida panther (Felis concolor coryi), of which there remain about 30. The Florida panther's potential inbreeding problems could possibly be stemmed somewhat by a corridor system, but it is far from certain that even an extensive system will save this animal, and the cost of such a system would lessen the resources that could be devoted to land acquisition and other means of aiding many other threatened species.

Resumen: *Existen pocos datos probados con los cuales evaluar el rol para con la conservación, de los corredores que conectan los refugios naturales. Si los corredores se usaran suficientemente, esto reduciría las amenazas de depresión endogamica y la estocasticidad demográfica. Para las especies que requieren mas recursos que los disponibles en un solo refugio, una red de refugios conectados por corredores asegurara la persistencia de estas. Finalmente, un corredor, como por ejemplo un bosque ripario (de galeria) puede constituir un importante región por sí mismo. La escasez de información acerca de hasta qué punto las especies utilizan estos recursos dificulta la determinación de las ventajas potenciales para cada caso. Algunos estudios de campo indican que ciertas especies utilizan los corredores, no obstante que la falta de controles experimentales precluyen afirmaciones que los corredores previenen la extincion.*

Aun cuando los corredores proveen beneficios potenciales, tambien pueden incurrir costos. Las enfermedades contagiosas, los incendios y otras catástrofes pueden ser transmitidas por los corredores. Estos pueden aumentar la vulnerabilidad de los animales y sus predatores, los animales domésticos y los cazadores furtivos. Los corredores pueden incurrir costos económicos. Por ejemplo, un puente que mantiene un corredor ribereño puede costar trece veces mas por carril/milla que una carretera que cortaria el corredor, y el manejo por unidad/area puede ser mayor que para los refugios. Puede ser mas costeable el manejar ciertas especies trasladándolas entre refugios que adquiriendo y manejando corredores.

Cada caso debe juzgarse por sus propios méritos porque las relaciones especie-ambiente son tan diferentes. Queremos usar el caso de la pantera de Florida como ejemplo (Felis concolor coryi). Quedan aproximadamente 30 individuos de esta especie y es posible que los problemas potenciales de depresión endogamica puedan ser disminuidos con un sistema de corredores. Sin embargo, no es seguro que un sistema extensivo de corredores pueda salvar a esta especie y el costo reduciría los recursos disponibles destinados a la adquisición de tierras y otras formas de asistencia para otras especies amenazadas.

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Introduction

The Seychelles islands in the Indian Ocean contained 14 endemic land bird species when Europeans first arrived there in 1770. In the two centuries since then, land clearing, a series of fires, and introduction of predators such as rats and cats have devastated the archipelago. However, only the green parakeet *(Psittacula eupatria wardi)* and the chestnut-flanked white-eye *(Zosterops mayottensis semiflava)* have been extinguished (Penny 1974). Losses were limited partly because the Seychelles consists of several separate, small islands (fires and introduced predators were unable to reach all the islands). For example, the Seychelles magpie robin *(Copsychus sechellarum)* remains only on Frigate Island; feral cats have destroyed it elsewhere but were controlled on Frigate and cannot reinvade because of the water barrier.

We describe this example simply to point out that corridors connecting refuges are not always an unmitigated blessing. The idea that corridors should be maintained between refuges whenever possible was suggested by Wilson and Willis (1975) as a logical consequence of the equilibrium theory of island biogeography (MacArthur and Wilson 1967). This suggestion is the subject of our article.

Possible Advantages

The corridor recommendation is an automatic consequence of the equilibrium theory. This theory states that the number of species in an insular site (like a refuge) is a dynamic equilibrium between local, on-site extinction of resident species and occasional stochastic immigration to the site by species not currently resident. Thus the composition changes but the number of species stays approximately constant. According to the original equilibrium theory, corridors would act by increasing the immigration rate. Once a species is locally extinguished on a refuge, the expected time to the next reimmigration is lowered by the availability of corridors. On average, then, there would be more species present any time one censused the site. Wilson and Willis (1975) add that corridors will also maintain higher numbers of species in refuges because species that would otherwise have become extinct will be maintained by continuing reciprocal immigration from other sites (Fig. 1). This is a version of the phenomenon subsequently termed the "rescue effect" by Brown and Kodric-Brown (1977).

Harris (1984, 1985) suggested two other reasons why corridors should be part of conservation plans: 1) individuals of some species, especially large mammals, must

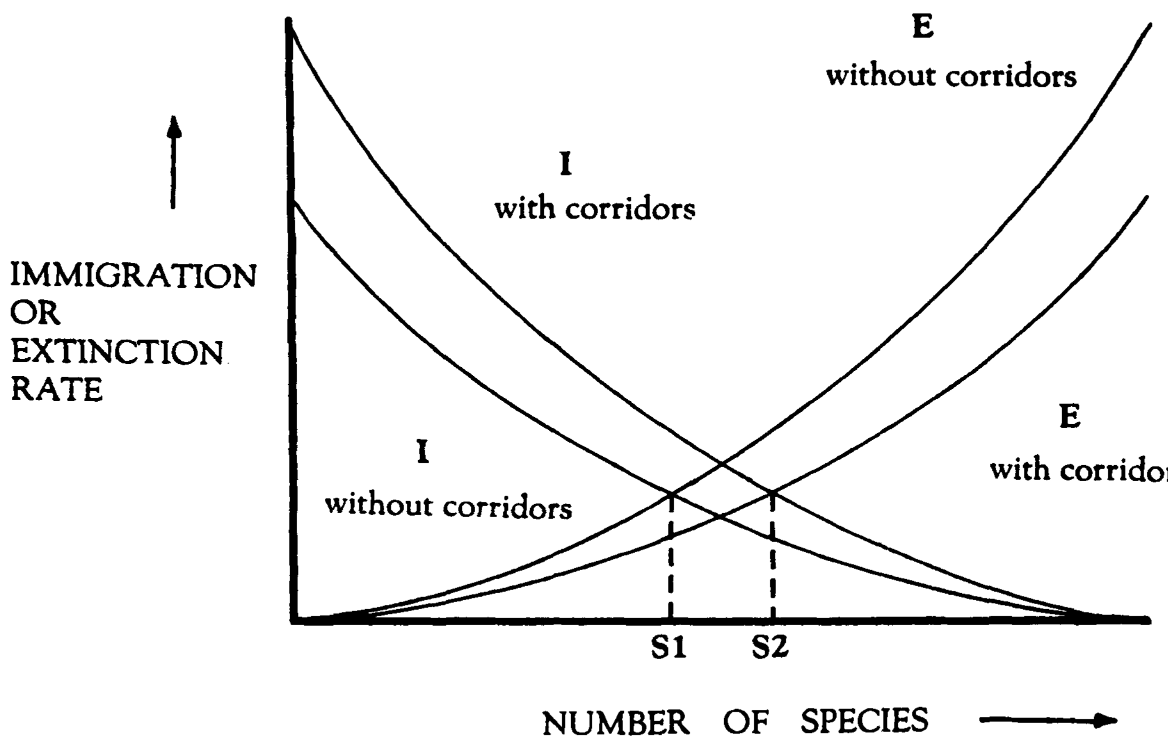

Figure 1. Effect of corridors on immigration rate (I), extinction rate (E), and resulting number of species in equilibrium island biogeographic model. S1 is equilibrium number of species without corridors. S2 is equilibrium number of species with corridors.

range widely in order to meet their food requirements (single, small refuges will not contain enough food), and 2) if population sizes within single refuges are too small, inbreeding depression will ensue and lead to extinction.

With respect to 1), if each individual of a species requires X calories of some food per year and a refuge produces only 20X calories per year, it is likely that the species cannot persist in this refuge alone even if all the food were available and the individuals were able to find all of it. This is the question of the minimum viable population (MVP) size consistent with long-term viability of the population. There are several stochastic reasons, such as temporal variation in demographic parameters, why very small populations are at much greater risk than larger ones (Shaffer 1981, Soulé and Simberloff 1986). If food within a refuge were limiting and if individuals within a population actually used the corridors to feed in other areas, a network of refuges might support a population where no one component within the network would have sufficed.

Inbreeding depression is more of a threat to small populations than large ones and could be alleviated by corridors. Although current consensus (May 1973, Shaffer 1981) is that demographic stochasticity is probably a much more important short-term danger to most threatened populations (e.g., National Research Council 1986, Dawson et al. 1986), inbreeding depression has often been demonstrated in small populations (e.g., Ralls and Ballou 1982*a*, 1982*b*, 1983) and must be considered as a possible threat. However, different species appear to tolerate inbreeding to different degrees (Ralls and Ballou 1983), and the sort of research that establishes the effect of inbreeding on fitness and even the existing degree of inbreeding is extremely difficult. The threat of extinction from demographic stochasticity could also be alleviated by corridors. Certainly it is alleviated by migration into populations via the "rescue effect" mentioned above. Fahring and Merriam (1985) modeled the performance of a white-footed mouse *(Peromyscus leucopus)* metapopulation with a range of deterministic birth and death rates and migration rates between populations in different simulated woodlots. Populations within the metapopulation that received no immigrants were more likely to become extinct than those that received immigrants. Fahring and Merriam also suggested that, as a matter of common sense, isolated populations that became extinct would be replaced more slowly than would connected populations that did so. Because local *Peromyscus leucopus* populations occasionally become extinct and because they are known to move occasionally between woodlots, this modeling approach may help to pinpoint the contribution of migration to population persistence.

One can easily envision the incorporation of corridors into such a model, although the results would be useful only for realistic values of corridor use: Do individuals move through the corridors and at what rates? The key additional feature required by such a model would be to substitute stochastic demography (birth rates, death rates, sex ratio, etc.) for the deterministic treatment, as suggested by Shaffer (1985) for the spotted owl *(Strix occidentalis)* metapopulation in the Pacific Northwest. Such stochastic variation would probably tend to increase the rate of local population extinction and thus enhance the role of migration. However, without data on use of migration corridors, even a simulation enlarged in this way would not be able to indicate how important corridors are.

Finally, if a corridor constitutes an important and dwindling habitat in its own right, as do some riparian corridors (Noss and Harris 1986), then the corridor can function as a refuge, and the benefits from this source must be taken into account. Forman (1983) argues that most North American transmission line corridors would constitute unique habitats for the species residing in them only if the rest of the land were forested, while hedgerows are unique habitats only when no large woods are present. Henderson et al. (1985) found that chipmunks *(Tamius striatus)* bred within fencerows even when nearby woods supported breeding populations. Whether a corridor is an important habitat in its own right is obviously a matter that depends on the target biota and surrounding habitat matrix.

Does Extinction Occur? To What Extent Are Corridors Used?

If the equilibrium theory model is to represent validly even part of the role of corridors as proposed by Wilson and Willis (1975), two criteria must be met. First, stochastic population extinction must be continual in the refuges at measurable rates in the short term. Second, there must be immigration through the corridors. In short, there must be "turnover." It is widely agreed that extinction will occur for refuges (Soulé and Simberloff 1986), although the probable rates of such extinction are in dispute (e.g., Soulé et al. 1979, East 1983; vs. Western and Ssemakula 1981, Boecklen and Gotelli 1984, Boecklen and Simberloff 1986). Part of the problem in estimating these rates is the lack of controlled experimental data, a lacuna that is being redressed (e.g., Lovejoy et al. 1983).

Whether particular kinds of corridors will actually be used by the organisms for which they are intended and whether they will be used at rates high enough to forestall extinction have generally not been considered as frequently as the question of extinction rates. Data are slight, and no consensus has emerged (Forman 1983). Rivers and riparian habitats are often suggested as corridors, but many deep forest species may not venture into these habitats (Frankel and Soulé 1981). For example, Harris (1984) recommends riparian corridors between stands of mature Douglas fir forest but the red tree vole *(Arborimus longicaudus)* and the California red-backed vole *(Clethrionomys californicus)* would probably avoid such corridors (Soulé and Simberloff 1986). Forman (1983) and Forman and Baudry (1984) report that plants and small mammals do not move along hedgerow corridors efficiently while some birds and larger mammals do. Harris (1985) argues that corridors such as the Bering land bridge and the Panamanian Isthmus have, over geological periods of time, served as conduits for entire biotae. However, it is difficult to see how this is relevant to present conservation needs. These historical land bridges are tens or hundreds of miles across and have persisted for thousands of years. Such corridors were much larger than most present or projected refuges! Many species have used these land bridges, but this does not imply they would use the kind of corridors currently envisioned in conservation planning.

Studies cited to support the contention that corridors actually increase immigration and/or decrease extinction and thus raise the number of species in a site are, upon close examination, often insufficiently controlled to demonstrate this point. For example, MacClintock et al. (1977) entitled their paper "Island biogeography and the habitat islands of eastern forest. II. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity." One would expect to see a design approximating one or more habitat islands a given distance from a source area and connected to the source by corridors, compared to one or more habitat islands equidistant from the same (or a similar) source but not connected by corridors. Instead, there are two forest islands connected to a large forest by a corridor, plus two quadrats within the large forest. There is no way to determine from data on these sites whether the corridor facilitated movement to the habitat islands.

In several studies, Merriam and coworkers have attempted to provide more control on whether small mammals use corridors (Wegner and Merriam 1979, Middleton and Merriam 1981, Henderson et al. 1985). They concluded that both chipmunks and white-footed mice probably use fencerows to move between woods and that this movement is important because populations in small woods probably are extinguished occasionally. The importance of the fencerows was indicated, particularly in the recolonization of woods from which chipmunks had been experimentally removed, but there is still some ambiguity in the results. For example, Henderson et al. (1985) found some colonizations to have required crossing 60 m of open pasture and some marked individuals to have moved about 1000 m and crossed a two-lane gravel road. In no instance was the same wood experimentally defaunated more than once and then recolonized with and without corridors. Nor were connected and unconnected woods defaunated. However, of all recorded movements between woods, fewer than 10 percent were not known to have required fencerows. It therefore seems likely that the fencerows facilitate both recolonization of areas in which populations have become extinct and the operation of the rescue effect to forestall such extinction.

Lee Harper (personal communication) has studied the effect of a corridor on ant birds (Formicariidae) in an experimental forest island of Brazilian rain forest (Lovejoy et al. 1983). The island, of approximately 100 ha, was connected by a 2 km corridor at least 100 m wide along a stream to a large rain forest. The island had been surveyed for at least a year before 300 m of the corridor was destroyed in August 1984. Three species of ant birds disappeared within four weeks even though army ants were still present. There was no control island for which the corridor was *not* severed, but using the same site over again as a temporal control is possible. Harper (personal communication) reports that, after a year of second growth in the corridor, one of the three ant bird species is beginning to recolonize.

Possible Disadvantages

So far we have spoken as if a set of corridors has few potential costs, only potential benefits. The equilibrium theory of island biogeography treats only a limited range of phenomena that might bear on extinction. It does not, for example, deal explicitly with genetics. We have already discussed potential benefits from corridors in addition to those predicted by the equilibrium theory. Several possible detrimental effects should also be considered.

First and foremost, the catastrophic contagious effects such as fires and introduced predators in the Seychelles have attracted much attention (Simberloff and Abele 1982). For example, the Solomon Islands' brown tree snake *(Bioga irregularis),* introduced to Guam during World War II, is eating its way through the island's avifauna (Jaffe 1985, Savidge 1985). This nocturnal predator has already eliminated the bridle white-eye *(Zosterops conspicillata)* and the rufous fantail flycatcher *(Rhipidura rufifrons)* from the island and threatens at least three other species. As in the Seychelles example cited earlier, one can imagine that if Guam consisted of several isolated, small islands instead of one large one, the snake's effect would be contained or at least greatly retarded.

Contagious diseases are another such agent of extinction; for example, 20 of the remaining 60 Javan rhinoceroses *(Rhinoceros sondiacus)* died of an unknown contagious disease in 1984 (*Oryx* 1984), and a key factor *in the extinction of the heath hen (Tympanuchus cupido cupido)* in the eastern United States was blackhead, a disease contagious among poultry, that ravaged the population, which had been gathered entirely in a single refuge on an island off Martha's Vineyard, Massachusetts

(Simberloff 1986). Needless to say, a corridor can transmit a disease, fire, or predator.

Second, corridors increase the exposure of animals to humans (facilitating poaching), domestic animals (facilitating diseases), and predators (Soulé and Simberloff 1986). If a corridor were thin enough, it would not be surprising if hunters used it, legally or illegally, by stationing themselves at appropriate locations. Both mule deer *(Odocoileus hemionus)* and Virginia white-tailed deer *(Odocoileus virginianus)*, for example, tend to follow specific routes, and hunters exploit this behavior by monitoring these routes. Bobcats tend to follow established routes quite closely. In Wyoming, during one 90-day period, 39 bobcats were trapped at one location through a catnip bait placed near a trail (Young 1978). Animal predators also patrol particular travel routes. For example, the eastern diamondback rattlesnake *(Crotalus adamanteus)* typically stations itself along frequently used mammal runs (D.B. Means, personal communication). Whether such threats should be a major concern would, of course, depend on the sorts of animals expected to use a corridor, the width of the corridor, potential predators, potential vectors of diseases, and a host of other factors.

Third, corridors can provide an entrée for weedy and opportunistic species into a forested habitat that might otherwise be closed to them (Noss and Harris 1986). In Florida, Maehr and Brady (1984) warn that black bears *(Ursus americanus)* may disperse Brazilian pepper *(Schinus terebinthifolius)*, a noxious exotic whose fruits are readily consumed by bears. Corridors proposed by Noss and Harris (1986) for bears and other large vertebrates may help to spread this plant. Janzen (1983) describes how facilitating movement of secondary successional species can lead to the gradual degradation of pristine tropical forest.

Fourth, highway right-of-way and median strip corridors can lead to lead poisoning (O'Neill et al. 1983), depending on the volume of traffic and the amount of time animals spend in such corridors, not to mention the potential death from collisions (Harris 1985).

Fifth, we must address the economic component of this issue. It costs something to purchase, maintain, and protect corridors. As one example, Harris (1985) argued that high bridges over rivers and highways will allow safe passage through the resultant corridors while planar intersections contribute to highway carnage. This contention is certainly true, but in Florida the average cost of a road is $500,000 per lane-mile, while the average cost of a bridge is $6.86 million per lane-mile, which is greater than a tenfold increase (Florida Department of Transportation, S. Burnett, personal communication). Other management costs are probably greater for corridors than for an equivalent area of refuge if only because corridors have more edge so their habitat is more likely to be influenced by the surrounding habitats. Just the cost of fencing alone would be far greater for a corridor than for an equal-size compact refuge. Maintaining plants can be another cost (e.g., Nilson 1977, Ericson 1979).

As Harris (1985) notes, "We can never buy, own, possess, or totally control enough land to preserve everything." Thus current conservation strategies are fraught with important, perhaps paramount, cost/benefit considerations. We must therefore ask how corridor acquisition and management complements or conflicts with the acquisition and management of isolated areas that have intrinsic biological values beyond their connective values. We should also consider the suggestion that the accretion of human development may soon hinder our abilities to acquire large reserves (Soulé and Simberloff 1986).

Corridors and Gene Flow

The facilitation of gene flow by corridors need not be automatically desirable. If separate populations of a species have characteristically different genotypes, such differences will tend to be broken down. Another example from the Seychelles avifauna (Penny 1974, Cade 1983) makes this point. The Seychelles turtledove *(Streptopelia picturata rostrata)* is a morphologically distinct subspecies of a widely ranging species. It differs greatly in color and size from the Madagascar subspecies *S.p. picturata*. The latter subspecies was introduced from Mauritius or Madagascar at least by the mid-nineteenth century (Long 1981) and has either replaced or diluted (through interbreeding) the native turtledove on all but two or three small, remote islands: Cousin, Cousine and possibly Frigate (Penny 1974). On these islands the genetic swamping was greatly slowed, but even here there has been sufficient recent introgression that the pure form of the turtledove can be found only in museums (Penny 1974). It is highly likely that, if the Seychelles had been connected by corridors of land, the destruction of its turtledove would have been much quicker.

The preservation of local genetic variants, which may be adapted to the local environment or simply the fortuitous product of the founder effect, genetic drift, or random mutation, may or may not be a paramount goal. Sometimes such preservation is of great symbolic value. Certainly the struggle of Disney World and a number of ornithologists to save at least a substantial fraction of the racial characteristics of the dusky seaside sparrow *(Ammodramus maritimus nigrescens)* falls in this category. As long as there was a chance of finding more individuals, the U.S. Fish and Wildlife Service would not sanction breeding the five remaining males with females of other subspecies in order to protect the genetic purity of the subspecies (Cade 1983, Wilford 1986). In the debate over the importance and cost of maintaining or resurrecting this form, the adaptive role of the threatened genotypes was also adduced. Even when the adaptive value of geographic variation has not been ascertained (e.g., the Florida panther, Belden 1985, Cristoffer and Eisenberg 1985, R. Noss, personal communication), the interest in unusual morphology alone may be sufficient to compel a wish to preserve a variant.

A concern of conservation genetics is whether loss of genetic variability in threatened species will hinder the ability of the species to evolve in response to future environmental change (Soulé and Simberloff 1986). Chesser (1983) points out that one possible strategy for maintaining genetic variability is to maintain a species as a collection of isolated populations, each containing a high frequency of a different allele. In this approach, the subdivision of a larger population allows the effects of genetic drift to assist in the maintenance of genetic variability in the species. The within-population variation decreases more quickly than it would in the single large population, but the among-population variation decreases much more slowly.

One problem with this strategy, of course, is that smaller, isolated populations can suffer inbreeding depression more quickly than would a united, larger population and can eventually disappear. Chesser et al. (1980) and Chesser (1983) suggest that by deliberate movement of small numbers of individuals from population to population the dangers of inbreeding can be greatly lessened. Just how many individuals should be moved, and in what direction, is a complicated matter resting on effective population sizes, selection coefficients, and the specific effects of inbreeding. For particular sets of these variables the number of individuals that must be transferred among populations can be surprisingly small—so small that it might be genetically advantageous and far less expensive to move individuals manually rather than to provide corridors. Translocation also allows managers to monitor closely the gene flow between populations. Transferring bird eggs from population to population, for example, is a relatively straightforward and inexpensive procedure for many species (James 1983, Logan and Nesbitt 1986). Even large vertebrates can be efficiently and inexpensively translocated under certain circumstances. For example, Weise et al. (1975) successfully moved timber wolves *(Canis lupus)* from Minnesota to Michigan, although illegal killings and collisions with cars eliminated all four transplanted individuals.

Another problem with balkanizing a threatened population is that each smaller population is more susceptible to extinction by stochastic processes and certain catastrophic events. As mentioned, if corridors increase the chances of the "rescue effect," then populations connected by corridors would persist longer than separated populations.

Deciding to split or to lump populations for these reasons involves the type of "risk analysis" that is becoming part of many conservation and management programs (Salwasser et al. 1984). At the heart of this analysis is estimating the relative chances of success under different conservation strategies before implementing a single course of action. As an example, by including genetical parameters in probabilistic demographic models (e.g., Shaffer 1985), a manager can estimate whether several small populations could maintain higher levels of genetic variability without experiencing many localized extinctions, or whether a single larger population could maintain reproductive vigor under reduced levels of genetic variability in future generations. It seems to us that this type of analysis is required before corridors are established.

An Example: The Florida Panther

A discussion of current conservation strategies for the Florida panther, which include a possible extensive corridor system (Cristoffer and Eisenberg 1985, Noss and Harris 1986), helps to illustrate the need for a careful assessment of all costs and benefits associated with corridor establishment.

The population of panthers in Florida has been reduced from a presettlement population of approximately 1400 (Cristoffer and Eisenberg 1985) to a vestigial population of perhaps as few as 30 isolated in as yet undeveloped areas of South Florida (Florida Game and Fresh Water Fish Commission Annual Research Report, 1985). The population was once contiguous with other North American populations and the adaptive significance of subspecific characteristics has not been established (Noss, personal communication; Belden 1985; Cristoffer and Eisenberg 1985).

One corridor system planned for the Florida panther and other wide-ranging mammals (Cristoffer and Eisenberg 1985, Noss and Harris 1986) envisions establishing a captive breeding program and releasing individuals into an integrated refuge system in North Florida. Two national forests, three national wildlife refuges, and several state and private land-holdings may be united in this effort, connected by riverine and coastal corridors of an undetermined width, some stretching nearly 130 km through unprotected areas (Noss and Harris 1986). Harris (1985) contends that this corridor system is essential in safeguarding the survival of many wide-ranging mammals, such as the panther and the black bear. Discussions on establishing corridors between panthers translocated to North Florida and panthers in South Florida have also begun (Noss, personal communication).

Many unresolved biological and monetary questions linger over this proposition. As Harris (1985) notes, "Virtually no research has been done to establish the necessary dispersal corridor widths [for mammals]," which leaves the value of any proposed corridors in question until considerable additional research is funded.

That panthers, bears, and many other wide-ranging mammals will move 50–130 km between refuges along riverine corridors seems especially uncertain without specifying extremely broad widths.

The cost of the captive breeding program for panthers has been estimated at over $2 million for 15 years (Grow 1984), and unexpected costs may be associated with preventing the spread of contagious diseases among connected populations (e.g., feline distemper is prevalent in the South Florida population) (Florida Game and Fresh Water Fish Commission Annual Research Report, 1985). It will also cost tens of millions of dollars to construct bridges and manage corridors to prevent road and illegal killings—the major sources of known mortality (Florida Game and Fresh Water Fish Commission Annual Research Report, 1985).

Expanding the current population size and range of Florida panthers seems essential to the animal's survival, but whether corridors are needed among translocated populations to offset problems of inbreeding depression is less certain. There is evidence that the South Florida population already suffers from genetic problems (as indicated by a very large percentage of abnormal sperm in panther semen) (Florida Game and Fresh Water Fish Commission Annual Research Report 1985), but a better method of preserving extant levels of genetic variability might be to isolate new translocated populations. Given the home range sizes for panthers presented by Harris (1985), two isolated populations of approximately 25 to 40 might be established on the two largest tracts of protected lands involved in the proposed system (which have already been acquired). Three populations of approximately 25 to 40 panthers could then be maintained and cross-bred selectively through a recurring captive breeding program. Without analysis of the various risks associated with these integrated or divided panther populations, it is difficult to determine the better strategy.

Finally, the cost of this proposed corridor system may detract from other valuable conservation and management efforts in Florida. Many areas in South Florida where panthers range are not currently protected and perhaps could be acquired with money spent on proposed corridors. The degree of human growth projected to occur in South Florida (Fernald 1981) certainly will threaten chances of purchasing large tracts later. Because panthers apparently prefer deciduous habitats, it has been recommended that panther reintroduction areas in North Florida be managed for "phasing out mature pines" (Cristoffer and Eisenberg 1985), although mature pines are the primary nesting habitat of the endangered red-cockaded woodpecker *(Picoides borealis)*. Also, Florida harbors hundreds of endemic species whose preservation may hinge upon the acquisition of isolated areas. Approximately 220 plant taxa (species and subspecies), seven freshwater fish species, seven amphibian and reptile species, seven subspecies of birds, three mammalian species, and hundreds of invertebrate species are endemic to Florida (Caire et al., in preparation). Little has been done to prepare conservation strategies or acquire isolated areas for many of these endemics, although they are very important in terms of regional or national conservation efforts (Kushlan 1979).

Conclusion

As we have stressed throughout the foregoing discussion, each potential corridor must be considered on its own merits; generalizations made from theoretical considerations cannot be universally applied. In some situations corridors may be of great use, and in others one can reasonably argue that they will be irrelevant or even detrimental. Unfortunately, much of the current literature concerning corridors fails to consider potential disadvantages and often assumes potential benefits without the support of sufficient biological data, or even explicit recognition that such data are needed. Costs seem often to have been ignored. It is very important, though, that decisions on these choices and other conservation matters be based on data or well-founded inference, not on overarching generalities. In particular, the matter of whether the same money and effort might be spent better in other ways deserves more consideration.

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