IMPORTANT CRITERIA AND PARAMETERS OF WILDLIFE MOVEMENT CORRIDORS - A PARTIAL LITERATURE REVIEW

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Introduction

Some of the most recent literature on wildlife movement corridors was reviewed and summarized to provide a better understanding of important evaluation criteria and design parameters for corridors. The summary includes a section on "Criteria for Evaluating and Designing Corridors" and a list of important parameters that can be used by environmentalists and land use planners to design, map, and monitor inter-refuge wildlife corridors on the landscape. Also included in the summary are sections on arguments for and against corridors, important questions to ask when designing corridors, and priorities for future corridor research.

Current Wildlife Movement Corridor Definitions

Current definitions emphasize that a wildlife corridor is a linear landscape element which serves as a linkage between historically connected habitat/natural areas, and is meant to facilitate movement between these natural areas (McEuen, 1993).

Arguments for Corridors

McEuen (1993) provides a review of both the history of and current wildlife corridor theory that includes a number of arguments for and against wildlife corridors. The possible conservation benefits of linking reserves with corridors listed in her review are as follows:

1. *Enhanced immigration*, which would enhance gene flow, increase genetic diversity, allow recolonization of extinct patches, and enhance overall metapopulation survival in connected patches.
    - This is related to the "rescue effect" concept in which immigration decreases the extinction risk of an isolated population by boosting local numbers and increasing genetic diversity which leads to increased fitness and survival.
    - Beier (1993) observed through modeling that the presence of a corridor allowing even low levels of immigration improved the probability of survival of a cougar population in Southern California.
2. The opportunity for some species to avoid predation.
3. Accommodation of range shifts due to climate change.
4. Provision of a fire escape function.
5. Maintenance of ecological process connectivity.

The fact that the natural landscape had been connected in the past may be the best argument for corridors (Noss 1987 as cited in McEuen. 1993).

Arguments Against Corridors

Critics of corridors feel that the corridor concept has been prematurely accepted despite the absence of data on corridor use, insufficient and/or inconclusive corridor research, and the failure to consider possible negative impacts of corridors. McEuen (1993), in her review of wildlife corridor theory, lists a number of arguments by several authors against wildlife corridors. Simberloff et a1(1992) question the rationales for movement corridors and suggest that evidence for corridor use is ambiguous or lacking. The authors also discuss the potential biological disadvantages of corridors which are included in the following list of arguments against corridors:

1. Paucity of data on corridor use and a lack of sufficient controls in corridor field studies
2. Paucity of data on significance of loss of genetic variation due to inbreeding and in small populations
3. The establishment of smaller reserves as a result of corridors
    - There is the possibility of a loss of genetic variation due to genetic drift in an ensemble of smaller refuges that would be greater than the gain in genetic diversity due to immigration and gene flow through corridors. *NOTE: Genetic drift is the change in genetic composition of populations that result from random effects (random combinations of parent genes in the next generation)*
4. Habitat unsuitability of corridors (i.e. riparian corridors will not serve as a conduit for non-riparian species)
5. High rates of poaching or trapping in corridors
6. Increased exposure to domestic animals harboring disease
7. Avenues for the spread of catastrophes (predators, fire, disease) may be provided through corridors
    - corridors have a high fraction of edge habitat and may attract edge-inhabiting predators
    - the negation of the quarantine effect of isolation would allow disease to spread between populations
8. Entry routes, avenues, and reservoirs for weedy or exotic species may potentially be provided by corridors
    - some corridors may favor movement by introduced species
9. Corridors may function as genetic traps or sinks

- low quality (habitat) corridors could act as genetic sinks due to increased mortality. resulting in local extinctions and a decrease in the size of a metapopulation

10. Economic factors, including higher management costs due to high edge-inferior ratio and the cost of building bridges over corridors
    - preserving corridors may not be the most cost-effective way to facilitate survival of all conservation-priority target species
    - relocation of animals might be as effective as corridors and less costly
11. Conflict with other conservation acquisitions
    - Is preserving corridors sufficient to maintain species viability where wildlife refuges are insufficient ?
    - Is a corridor the only or even the best way to provide whatever movement is necessary between populations?
    - Does preserving corridors foster the belief that one has done enough and need not preserve larger tracts of valuable habitat?
12. The theory of central place foraging predicts that species with colonial social structure and that consume widely dispersed food may be disadvantaged in narrow, linear-shaped habitats (Lindenmayer and Nix, 1992). The authors observed that arboreal marsupials in Southeastern Australia with this type of social structure and foraging pattern were rarely encountered in corridors. This study indicates that some species may be poorly conserved by a network of reserves and wildlife corridors, hence wildlife corridors alone may be insufficient as a strategy for nature conservation.

Critics of the corridor concept also pose the following philosophical questions:

- Although the concept of corridors is easily understood, is it good conservation biology to sell legislators and the public on the easiest program for them to understand, in the absence of evidence that it is the most effective one?
- Is it beneficial for people to feel they are doing something important for conservation by preserving corridors in the absence of evidence that they really are doing something ?

Conservation-Strategy Alternatives to Corridors

General alternative strategies to wildlife corridors have been proposed to facilitate population survival where refuges alone are insufficient. Several of these strategies suggested by Simberloff et al (1992)consist of:

- providing a network of unconnected patches of forest or "stepping stone" remnants to facilitate the persistence of populations
  - ⇒ "stepping stone" patches on their own, or in conjunction with corridors, could be part of an entire landscape managed for both extraction and conservation
- managing the entire landscape as a matrix that supports the entire biotic community

⇒ Thomas et al (1990), as cited in Simberloff et al (1992), suggest managing the entire matrix surrounding Northern Sported Owl habitat conservation areas to make it suitable for owl dispersal in random directions

⇒ it is important to determine the life-histories and habitats of target species before attempting this type of conservation strategy

DESPITE CRITICISMS OF THE CORRIDOR CONCEPT AND ARGUMENTS AGAINST CORRIDORS, MOST RECENT THEORISTS HAVE SIDED IN FAVOR OF CORRIDORS AND FEEL THAT, ALTHOUGH BY NO MEANS PERFECT, THEY ARE THE BEST SOLUTION TO A COMPLEX PROBLEM (McEuen. 1993).

Important Questions To Ask When Designing Corridors

Which types of species (species groups) utilize corridors?

How does residency within corridors and movement rates through corridors differ among species groups?

How does utilization by species groups change with changing corridor conditions (shape, width, length, location, and vegetation composition)?

How do habitat requirements and a species' perception of the environment affect the utility of corridors, for example, does a particular target species have the ability to distinguish and utilize a corridor?

Will corridors provide avenues of movement for exotic species and disease as well as for native target species?

What types of wildlife movement and habitat do you want to conserve within corridors, i.e. what are the conservation goals for a particular corridor?

Criteria and Parameters For Evaluating and Designing Corridors

Species Groups and Target Species

When evaluating a corridor, it is important to determine which species the corridor will serve. Corridor use can be evaluated with respect to both broad species groups or specific target species.

McEuen (1993) groups potential corridor users into six species categories that might be important to corridor theory and research. The categories include:

- edge vs. interior species
- exotic vs. native species
- regionally abundant vs. regionally rare species
- generalists vs. specialists
- coarse-grain vs. fine-grain species
- naturally fragmented vs. naturally continuous habitat species

Beier and Loe (1992) group corridor users into two general types: passage species and corridor dwellers. Passage species include large herbivores and medium to large carnivores that need corridors to allow individuals to pass directly between two areas in discrete events of brief duration. For these species. corridors facilitate juvenile dispersal. seasonal migration and home range connectivity. Corridor dwellers include species with limited dispersal ability that take several days to several generations to pass through a corridor. These species must be able to live in the corridor for extended periods. Therefore, the corridor must provide most or all of the species' life-history requirements. Corridor dwellers include most plants, reptiles, amphibians, insects, small mammals, and birds with limited dispersal ability.

A target species may be any species that has the greatest need for a corridor to survive, or an “umbrella species" whose protection will likely provide benefits to the greatest number of other species. Current wildlife corridor theorists place an increased emphasis on the need to design corridors specifically for native, conservation-priority target species. Beier and Loe (1992) reinforce the importance of the target species by stating that the species of interest is the most important factor of a number of parameters used to determine corridor width.

Movement and Habitat Types

Stenseth and Lidicker (1992), as cited in McEuen (1993), refer to three types of movement in corridors and three types of habitat. The three types of movement include:

- *dispersal* . . . one way movement away from a home site
- *migration* . . . round trip movements
- *home range* movements

The three habitat types include:

- *transitional habitat* . . . suitable only for movement of a disperser
- *marginal habitat* . . . allows survival and sometimes reproduction
- *survival habitat* . . . “good habitat" in which both survival and reproduction can occur

The two types of corridor users described by Beier and Loe (1992) in the above section are compatible with these movement and habitat types. Passage species demonstrate dispersal and migration movements and may utilize all three habitat types. Corridor dwellers have home range movements and would use the survival, and to a lesser extent, the marginal habitat types.

Models for Corridor Movement

Based on the different types of movement and habitat, McEuen (1993) proposes two models for corridor movement. Model A illustrates that a corridor consisting of transitional habitat facilitates only dispersal and migration movements of passage species. Model B shows that a corridor containing survival habitat throughout facilitates residency of corridor dwellers throughout the corridor, with home range movements occurring entirely within the corridor.

In Model A, length and optimal width of a corridor are critical issues, since dispersers must reach the other patch to reproduce. Increased length and width (beyond optimum) would reduce chances of dispersers reaching a connected parch. In Model B, length and optimal width of a corridor are no longer issues because there is no need for an individual to reach the other patch. Minimum width, based on edge-effects, may still be a critical parameter in this model.

Important Criteria For Evaluating The Suitability Of Corridors

Beier and Loe (1992) suggest five functional criteria that can be used to evaluate corridor suitability. Corridors are considered suitable for wildlife movements if they provide avenues along which:

1. wide-ranging animals can travel, migrate and meet mates
2. plants can propagate
3. generic interchange can occur
4. populations can move in response to environmental changes and natural disasters
5. individuals can recolonize habitats from which populations have been locally extirpated

These five functions should be used to evaluate the suitability of land as a wildlife corridor. A corridor is suitable when it meets the five functions for each target species.

Beier and Loe (1992) also provide a checklist for evaluating and designing corridors. The checklist can be used as a means to improve the treatment of wildlife corridors in environmental impact analyses of development activities such as roads, power and gas pipeline corridors, logging, mining, recreation facilities, urbanization, clearing for agriculture, etc. Observations made by other researchers are included in the checklist to embellish upon certain points.

A Checklist for Evaluating and Designing Corridors

1. **Identify the habitat areas (specific target areas) the corridor is designed to connect.** Determine if the areas will remain suitable habitat in the future.

2. **Select several species of interest (target species) from the species present in these areas.** Focus on "umbrella species" whose protection is expected to provide benefits to the greatest number of species, and on species that have the greatest need for a corridor for survival.

3. **Evaluate the relevant needs of each selected species.** For passage species, identify movement and dispersal patterns. including seasonal migrations, of local animals. For corridor dwellers, identify habitat needs including special needs such as nesting, rearing, or germination sites, as well as dispersal or migratory patterns of the animals.

- Examination of movement pattern during natal dispersal can provide insights into the requirements of corridors (Harrison 1992).
- The level of predation risk strongly affects dispersal patterns and must be considered in corridor design (Harrison 1992).
- Lindenmayer and Nix (1992) state that the effectiveness of wildlife corridors may be improved by considering the social structure, diet, and foraging patterns of target species

4. **For each potential corridor. evaluate how the area will accommodate movement by each species of interest (i.e. evaluate availability of suitable habitat).** Important questions to consider for both passage species and corridor dwellers are as follows:
   - Given the animals' movement patterns, are the topography, vegetation and location of the corridor such that individuals will encounter, enter and follow or live in the corridor?
   - Is there sufficient shelter, cover, food, and water for passage species animals to reach the other end?
   - Does the habitat meet the life-history needs of corridor dwellers?
   - What are the current and future impediments to use of the corridor (i.e. gaps, domestic animals, and human activities)?
   - The effectiveness of wildlife corridors may be improved by considering <u>the landscape context of a corridor</u> (Lindenmayer and Nix. 1992). Successional changes affecting suitability of habitat in areas adjacent to a corridor may influence the use of the retained area by wildlife. Such changes highlight the potential influence of the status of a surrounding area on the biota within a corridor, and thus the landscape context of a wildlife corridor. The landscape context criteria may also indicate the need for buffer zones around wildlife corridors.
   - For wildlife corridors to alleviate the effects of global warming, regional corridors may need to preserve entire communities and serve as habitat that permits survival and breeding for passage species as well as corridor dwellers, not just linkages for movement (Simberloff et al, 1992).

5. **Draw the corridor(s) on a map.** Effective protection of wildlife corridors requires putting them on a map. This step includes connecting larger habitat areas, stating the corridor widths, describing the vegetation and topography, and explaining how each corridor meets the needs of target species. It is also important to <u>specific management guidelines</u> for each corridor.
   - Important management guideline questions to consider during this step include:
     - ⇒ Are there any prohibitions on land uses within the corridor that will impede functioning as a corridor (i.e. approved logging plans for the next 1-2 years)?
     - ⇒ What land uses may be permitted adjacent to the corridor?
     - ⇒ How should domestic animals and human activities be controlled in and adjacent to corridors?

- ⇒ How should future road crossings be designed (i.e. minimize crossings and include underpasses and animal guide fences)?
- ⇒ What recommended changes can be made to enhance the utility of the corridor (i.e. restoration)?

- Use a geographic information system (GIS) that covers a regional landscape for putting wildlife corridors and other critical habitat on planners' maps. GIS provides the only efficient means of addressing cumulative impacts and an accessible forum on which developers, conservationists, and other citizens can express their vision of the regional landscape.

6. **Design a monitoring program.** This step includes monitoring animal use of each project-impacted corridor to determine the failure or success of various designs. Monitoring will yield the data needed to preserve or create functional corridors in the future. Monitoring programs can include track monitoring, photography, radiotelemetry, and measures of gene flow.

- Monitoring for corridor use should occur:
  - ⇒ before and after a development project
  - ⇒ on the adjacent matrix outside the corridor before and after development
  - ⇒ to determine preproject use of any forfeited corridor that will be destroyed by a project
  - ⇒ on at least one undisturbed corridor, before and after development, to provide a control for effects that might affect animal movement

NO WILDLIFE CORRIDOR DESIGN SHOULD 8E APPROVED WITHOUT MANDATING THAT THE PROJECT PROPONENT FUND MONITORING PROGRAMS TO DETERMINE USE OF THE PROPOSED CORRIDOR

Site-specific data (utilization of corridor) in conjunction with model conclusions is sufficient documentation to protect a corridor. In a study to determine minimum habitat areas and habitat corridors for cougars in Southern California, Beier (1993) collected site-specific data using radio telemetry to confirm use of corridors by cougars in the Santa Ana Mountain Range. The field study showed that telemetered cougars could quickly identify movement corridors.

Important Corridor Design Parameters

A number of parameters have been observed to be important in affecting wildlife movements in recent wildlife corridor research studies. Some of the most important parameters are listed below.

Habitat:

Habitat has been observed to be a critical design parameter of corridors. The extent to which a corridor will be used by dispersers depends upon the habitat within the landscape linkage.

It is important to have patches connected by "high-quality" habitat that provides for both species survival and reproduction. Henein and Merriam (1990) observed that for two isolated parches, increasing the number of high quality corridors increased metapopulation size, while adding low-quality habitat corridors actually decreased metapopulation size. They also observed that the addition to a metapopulation of a patch connected by a low-quality corridor had a negative effect on the metapopulation size, indicating increased mortality during movement.

Dispersal patterns for some prey and associated predator species indicate that effective corridors must contain enough "suitable habitat" for the target species to reside permanently within the corridor and to permit normal dispersal (Harrison 1992).
NOTE: "suitable habitat" Is synonymous with "high-quality" habitat and "good habitat".

Continuous "suitable habitat" corridors are preferable to facilitate wildlife movements as corridor function is thought to be hindered by the presence of gaps. Data from Lovejoy et al (1986), as cited in McEuen (1993), supports this theory. Harrison (1992) also states that gaps between suitable habitat should be small relative to dispersal distances. A CORRIDOR IS ONLY AS STRONG AS ITS WEAKEST LINK (Beier, 1993).

- A strong tendency to remain within suitable habitat while dispersing has been observed in studies of several species of rodents (Harrison, 1992).

Several wildlife species indicated a preference for wider and more complex vegetation corridors, as shown in recent studies that observed the combined effects of width and vegetation composition on corridor use (McEuen 1993).

Corridor Shape:

Linear corridor shape was found to be superior to all other shapes modeled in the first theoretical model on corridor capability developed by Soule and Gilpin (1991) as cited in McEuen (1993).

Corridor Width:

Corridors may have an optimum width determined by edge effect and the tendency of dispersing animals to wander (Soule and Gilpin, 1991, as cited in McEuen, 1993). Minimum widths of corridors may be estimated from data on target species home range sizes and shapes as well as considering widths necessary to maintain desired habitat against penetration of other vegetation types from edges (Harrison, 1992). Harrison also suggests that if a corridor is to contain enough suitable habitat for a given species to permanently occupy the corridor, then the corridor must be at least as wide as the width of one home range and contain home ranges that are designed to be rectangular and twice as long as wide.

Corridor Length:

Effective corridors may be narrower than minimum width based on home range size if they are less than the length of one average home range, so that dispersers may pass through without foraging (Harrison, 1992).

Corridor Location:

The location of a corridor may be affected by the relationship between seasonal movement patterns and the specific purpose of the corridor (Harrison, 1992). For example, it is important to locate corridors for migrating or wide-ranging species using seasonal ranges based on the time of migration or dispersal. Corridor location may be different for the different sexes of the same target species. It is also important to align corridors with other habitats that are suitable to the target species (Beier and Loe, 1992).

Landscape Context:

The "context" of the wildlife corridors in the landscape may be important for corridor use. In a study on arboreal marsupials in southeastern Australia, Lindenmayer and Nix (1992) observed that wildlife corridors that contained a variety of topographic positions (i.e. gullies to ridges) supported more species and a greater abundance of animals than sites confined to a single topographic position, such as a midslope. This study indicates that landscape connectors with a variety of sites due topography have higher habitat, and hence, species, diversity.

Human Activities:

The effectiveness of corridors will be affected by the type and extent of human activities and land use practices both within and adjacent to the corridor (Harrison, 1992).

Important considerations include:

- the impact of hunting and trapping (both legal and illegal), intrusion of domestic dogs, livestock grazing, and disturbance due simply to human presence
- the greatest human impact will occur near towns and along roads and edges where access to the corridor is easily available
- the type of human development, such as agrarian or industrial, in the vicinity of corridors will affect the extent of harmful and illegal activities

CORRIDOR DESIGN MAY HAVE TO INCLUDE BUFFER ZONES TO REDUCE UNDESIRABLE HUMAN ACTIVITIES

Priorities for Future Corridor Research

Harrison (1992) states that our knowledge of the basic principles determining the effectiveness of corridors is extremely limited and we need much more data on dispersal patterns and the use of natural corridors. He suggests the following list of critical research needs:

- monitor movements of dispersing wildlife continually in relation to habitat type, topographic features, and territories of conspecifics
- investigate cues used to determine dispersal direction
- investigate mortality and movement patterns in unsuitable habitat to determine the effect of gaps between refuges

- identify and monitor potential natural corridors such as riparian zones for dispersal movements
- determine the minimum width of effective corridors, possibly by measuring the minimum width of home ranges
- quantify the impact of human activities on wildlife populations as a function of activity and distance from roads and other developed sites

Bier and Loe (1992) suggest that future research should investigate:

- home range sizes, movement, dispersal, and habitat use patterns of target species
- minimum widths for corridors for target species based on corridor length, topography, and vegetation, and corridor location

Simberloff et al (1992) state that the value of corridors for maintaining biological diversity depends on the relative costs and benefits of a proposed corridor and alternate uses of the funds, such as purchasing wildlife habitat refuges. To date, no thorough cost-benefit analysis on the importance of movement through corridors has ever been done. Limited resources will almost certainly limit conservation strategy options. Consequently, one must be willing to set priorities, and these should be based on relative costs and benefits. Cost-benefit analyses on wildlife corridors and alternative strategies that can facilitate the setting of conservation priorities is another critical research need for the future.

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