ECOLOGY AND ECONOMICS RESEARCH DEPARTMENT

FEBRUARY 2004 • Number 1

THE WILDERNESS SOCIETY

Science & Policy Brief

Landscape Connectivity: An Essential Element of Land Management

Key points:

- Loss of habitat connections across a landscape is one of the most severe threats to the survival of many wildlife species.
- Each species has evolved different needs for connectivity; to help sustain viable populations, it is essential to understand those specific needs.
- Conservation ecologists are focusing on: (1) protection of corridors that link isolated habitat patches and (2) maintenance of natural conditions in the "matrix" (land surrounding intact habitat) to ensure sufficient landscape connectivity.

Background

Landscape connectivity has become a vital component in conservation science and land management planning, especially as human activities continue to reduce the size of natural areas and isolate them from one another. Significant consequences of those activities include isolation of populations of native species and disruption of their natural movements, dispersal patterns, and gene flows. To sustain these vital processes, and thus help species survive, it is imperative to maintain landscape connections among isolated areas.

This Science & Policy Brief contains basic information about landscape connectivity and discusses how it can be used in conservation strategies.

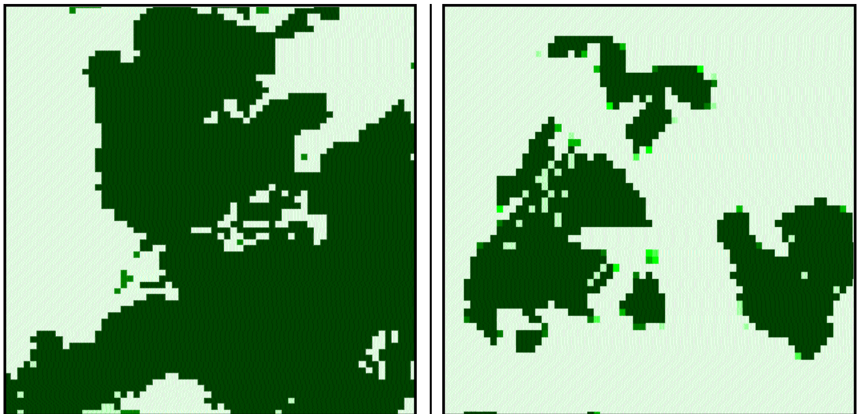
What Is Landscape Connectivity?

Landscape ecologists define landscape connectivity as the degree to which the structure of a landscape helps or hinders the movement of wildlife species. A landscape is considered "well connected" when organisms (or natural processes) can readily move among habitat patches over the long term.

PHOTO BY SUSAN HANNON

This agricultural landscape, located near Lac La Biche in Alberta, Canada, is typical of landscape fragmentation caused by human activity in many rural areas. It illustrates a mixture of isolated habitat patches, potential dispersal corridors, and — for many wildlife species — inhospitable habitat consisting of cropland, roads, and farm structures.

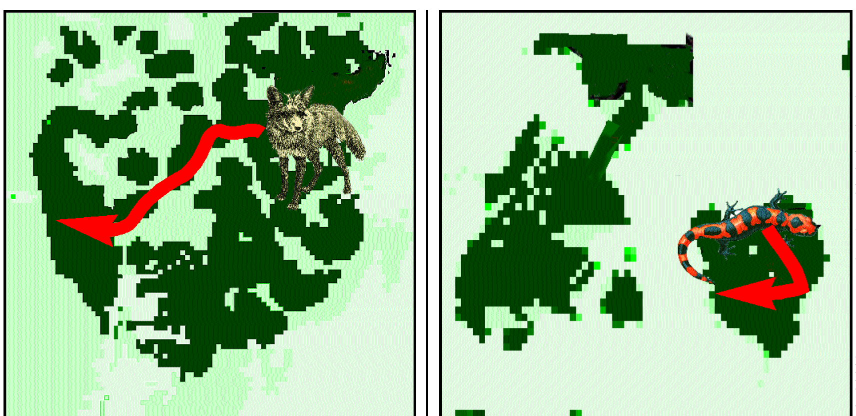
FIGURE 1.
In this simplified rendering of the basic concepts of landscape connectivity, the darker greens represent natural forested areas (patches), while the lighter greens represent surrounding human developments (matrix).



(a) Connected. Naturally forested land with a high level of connectivity: species can move through the forested area without crossing into the matrix.

(b) Unconnected. Unconnected forested areas: species cannot move from one patch to another unless they enter the matrix.

FIGURE 2.



SALAMANDER ILLUSTRATION © MONA CARON

(a) In this landscape, the fox can move among connected patches of high-quality, undisturbed forest habitat (dark green), forested land with some disturbance (medium green), and inhospitable matrix (light green).

(b) The salamander is unable to move outside an isolated habitat patch (dark green) surrounded by an inhospitable matrix (light green).

Landscapes are made up of mosaics of different patch types with varying physical attributes. This means that connectivity is not merely an element of the landscape; it is also an attribute of each patch. The movements of species across a landscape are influenced by the composition (type of forest, tree density, etc.) of each patch in the mosaic. Therefore, when identifying connections across a landscape, ecologists and land managers must consider the structure of that landscape.

Loss of landscape connectivity, commonly known as landscape fragmentation, is among the most severe threats to the survival of many wildlife species. Landscape fragmentation occurs when an area of relatively continuous habitat is lost altogether or is divided into smaller parcels. As habitat is lost or fragmented, residual habitat patches become smaller and more isolated from each other. This limits the movement of species and, through their increased isolation, puts them at greater risk of disappearing from a region.

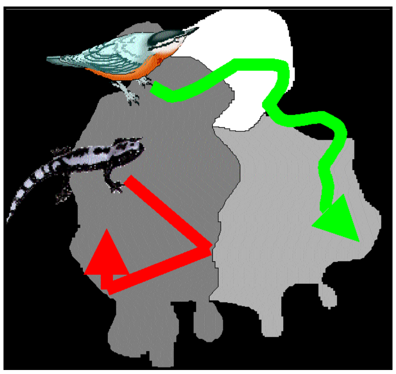
Figures 1 illustrates these principles. When a large forested area (Fig. 1a) is converted to other land uses, the forest is divided into smaller fragments, or patches (Fig. 1b). This reduces available habitat for species that rely on forest habitat and creates barriers to the movement of species among patches. Roads, logging operations, oil and gas drilling pads, the clearing of land for crops and housing developments, and other forms of human activity are primary causes of habitat loss and fragmentation.

Level of Connectivity

High levels of connectivity usually mean greater potential for species to move among different habitats and maintain healthy populations. To help ensure the movement of species across a landscape, connections that provide the opportunity for dispersal must be identified. It is also necessary to recognize barriers to movement. For example, dams function as barriers to migrating fish, and roads create barriers for many migrating terrestrial animals.

Each species has evolved needs for different levels of connectivity. Depending on the species, a given landscape may contain patches varying from high-quality habitat to lower-quality habitat or

FIGURE 3.
The bird perceives all patches within the landscape as suitable for movement, while the salamander views the dark gray patch as its only option for habitat and restricts its movement to that patch.



fragments that can act as barriers to movement. Some species do not restrict their movements to certain patches; rather, they move across an entire landscape — even traversing the matrix — to find high-quality habitat (Fig. 2a). In other cases, a landscape may be so fragmented and patches so isolated that a species cannot move outside an occupied patch (Fig. 2b).

Whether a species can use a patch for high-quality habitat or for dispersal depends on the level of connectivity that the species needs. Studies indicate that the pine marten (*Martes americana*) prefers to move through non-forested patches less than 30 meters in width and generally will not cross wider non-forested patches for fear of predators. On the other hand, elk (*Cervus elaphus*) normally will cross openings more than 30 meters in width. And, as illustrated in Figure 3, many bird species have a different perception of landscape connectivity than do salamanders.

As landscapes become more fragmented and as more habitat is lost, species may find that they must travel over a larger area and likely through a more hostile matrix to meet their living requirements. To help sustain populations of species, it is essential to understand how different species use and move through landscapes and to identify important landscape connections for different species.

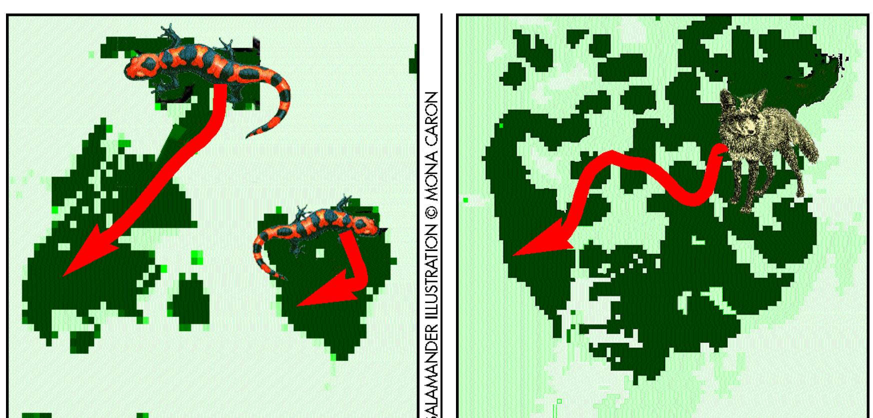
Measuring Landscape Connectivity

Quantifying landscape connectivity can be a tedious and complex task. But new methods are underway, and with the advent of landscape metrics it is possible to quantify connectivity for landscapes, land cover types (forest and vegetation types), species habitat types, species movement, and ecosystem processes across a given region.

Particularly helpful are the metrics that quantify the spatial characteristics (area and configuration of patches) of landscapes. While there are many such metrics, each lends new information as to how a species may move within a landscape — whether the species is affected primarily by patch isolation or patch aggregation across the landscape or largely by patch size or patch shape.

We suggest that readers consult FRAGSTATS, a computer program developed by McGarigal and Marks, for

FIGURE 4.



(a) A natural corridor helps the salamander at the top of the diagram move among isolated habitat patches (dark green) through a hostile matrix (light green), but the other salamander remains in its isolated patch.

(b) The arrow shows how the fox might perceive certain patches as dispersal habitat (medium green) and use those patches to move across the landscape, including the matrix, (light green), to suitable habitat (dark green).

more information about landscape metrics and how to quantify the spatial attributes of landscapes (see <http://www.umass.edu/landeco/research/fragstats/fragstats.html>).

Landscape Connectivity and Conservation

Corridors. In recent years, conservation ecologists have focused on two potential solutions to the loss of connectivity across fragmented landscapes. The first is the use of corridors — areas of habitat that link similar habitat patches in a landscape and are believed to facilitate the movement of species among isolated habitat patches. Corridors can be natural features such as a narrow strip of forest or a riparian area (Fig. 4a). They can also be structures such as the elevated highway segments built along Alligator Alley (I-75) in Big Cypress National Preserve to allow the endangered Florida panther (*Felis concolor coryi*) safe movement corridors underneath or landscaped overpass corridors such as those in Canada's Banff National Park to provide cover for the movement of many species — from bears to songbirds.

The main benefit of corridors is the dispersal habitat they provide between habitat patches, which allows exchanges among isolated sub-populations of species. This is important for many species, including the pronghorn antelope (*Antilocapra americana*). Studies show that pronghorns in Wyoming depend on natural corridors for migration and to ensure genetic variation among isolated sub-populations. The downside of corridors is that they may facilitate the spread of disease and predators to isolated populations.

Conservation ecologists are focusing on the roles that corridors and the matrix play in landscape connectivity.

More information is needed on how animals move and respond to corridor configurations and on the extent to which corridors reduce fragmentation effects. At present, few studies address these issues. Still, it appears that corridors are valuable in resolving species-specific fragmentation issues.

PHOTO: CHUCK BARTLEBAUGH, CENTER FOR WILDLIFE INFORMATION <BEARINFO@QUEST.NET>

A grizzly bear (*Ursus arctos*) attempts to cross a road, which poses an unnatural, high-risk barrier to the bear's natural movement. Vehicles have killed grizzlies in at least eight places near Yellowstone and Glacier national parks alone.

The matrix. Conservation ecologists are also focusing on the role of the matrix in connectivity and how it influences the movements of species across a landscape (Fig. 4b). Learning how species use variable habitat within the matrix will help identify important landscape connections in need of protection to promote the movement of species and to link sub-populations.

This approach has several advantages. Some species require large blocks of continuous habitat to meet their life requirements. They also require surrounding variable habitat within the matrix for movement. Thus, protection of a few remnant corridors may not be enough to provide needed connectivity. But maintaining large blocks of continuous habitats *and* variability in the surrounding matrix to aid the movement of species will help meet both habitat and connectivity needs.

Another benefit of the matrix approach is that knowledge of how species move through the matrix will help identify the natural conditions that they prefer for movement. Land managers can use such information to protect areas for connectivity needs and ensure that natural conditions will be maintained or mimicked in managed landscapes. Depending on how a species perceives connectivity, a fairly large part of the landscape might be composed of the matrix. It will be necessary to use the natural landscape and natural changes that occur on the landscape as guides to manage for species' movements throughout the entire landscape.

Much like corridors, few studies have analyzed the matrix's role in connectivity for many species. An investment in this approach could go far to advance sound landscape management and conservation of biodiversity.

Recommendations. When designing conservation reserves, land managers should consider all aspects of potential connectivity. Landscape and conservation ecologists recommend that land managers take the following into account when addressing landscape connectivity in their planning processes:

- Species that are well distributed across their native ranges are less susceptible to extinction than are species confined to small portions of their ranges.
- Large patches of habitat that contain large populations of species present a better opportunity to ensure the survival of species than do small patches with small populations.
- The orientation of habitat patches and the surrounding matrix are of vital concern. Habitat patches that are located close together allow for more exchange among individuals than do habitat patches that are far apart.
- Contiguous habitat promotes more movement of species and links among sub-populations than does fragmented habitat.
- Habitat patches that are interconnected through a variable matrix provide more connections than do isolated habitat patches surrounded by an inhospitable matrix.
- In attempts to sustain viable wildlife populations, habitat patches that are relatively inaccessible to humans are preferred over habitat patches that are accessible to humans (roaded areas).

In addition to the recommendations above, managers should: (1) maintain networks of corridors that incorporate existing links in the natural landscape and (2) manage landscapes and the matrix between corridors to sustain the natural conditions that species require for habitat and movements.

Landscape Connectivity in Practice

A number of conservation groups and land management agencies are beginning to incorporate the principles of landscape connectivity into planning processes. The Yellowstone to Yukon Conservation Initiative is identifying those landscape connections that are important to maintain movement of many species throughout the Rocky Mountain region north from Yellowstone National Park to the far reaches of western Canada. The effectiveness monitoring plan that the U.S. Forest Service adopted for the northern spotted owl in the Pacific Northwest assessed landscape connections among potential spotted owl habitat patches. That plan analyzed how owls may move through and use the matrix surrounding their preferred habitats.

There is still much to learn about landscape connectivity for a substantial number of species in many habitat types. Experience, research, and monitoring will improve understanding of this evolving and potentially powerful tool and allow the incorporation of vital information gleaned from landscape connectivity research into decisions about how land is best managed for conservation purposes.

A critical task in conservation is to gain an understanding of landscape connectivity *and* the importance of management actions that counteract threats to connectivity.

Suggested Readings

The following sources were used in writing this Science & Policy Brief. They contain useful information for readers who are interested in learning more about land connectivity and related issues.

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