Landscape Boundaries & Corridors

What boundaries do you see?

Boundaries?

Boundaries?

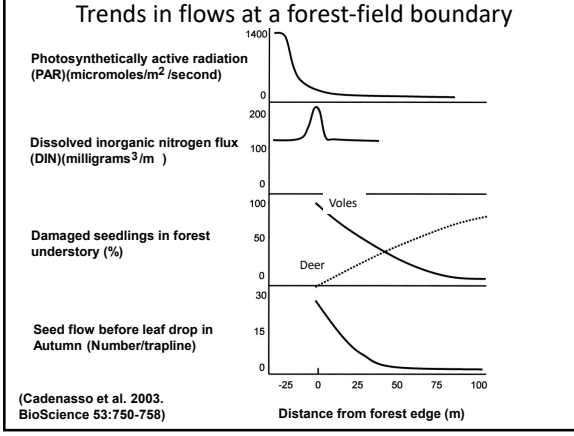
Boundaries

- Regulate flows of organisms, materials, energy and information across landscapes
- Importance is disproportionate to area occupied
- Characteristics
  - Different from adjacent patches
  - Magnitude of difference and location matters
  - Function depends on the flow
  - Steeper gradients than in the two adjoining areas
  - Wide or narrow
  - 3-dimensional
- Similar terms: edges, ecotones, gradients, clines, transition zones, interfaces

- "Edges are one of the most extensively researched areas of ecology" (Ries et al. 2004. Ann. Rev. Ecol. & Syst. 35:491-522.)

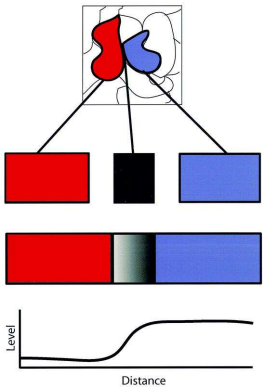
Cadenasso et al. 2003 BioScience 53:750-758

Trends in flows at a forest-field boundary



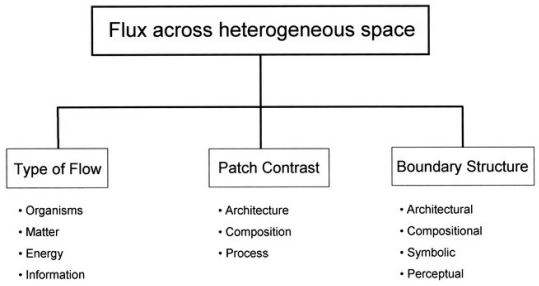
(Cadenasso et al. 2003. BioScience 53:750-758)

Model template for the study of boundary function



Cadenasso et al. 2003.

Conceptual framework for ecological boundaries



Cadenasso et al. 2003. BioScience 53:750-758

Ecological Boundaries: 4 Main Classes of Boundary Traits

- Origin and maintenance
- Spatial Structure
- Function
- Temporal dynamics

Strayer et al. 2003

Origination and maintenance

- Investigative or tangible
  - Did the boundary originate in a scientist's mind or in nature
- Causal or consequential
  - Fence vs a natural forest-field boundary
- Contemporary or relict
  - Arisen from forces still in operation or forces no longer operating
- Endogenous or exogenous origin
  - Does the boundary originate from processes operating within or outside of the system of patches (e.g. succession vs. lava flow)
- Endogenous or exogenous controls (maintenance or suppression)
  - Are internal or external forces maintaining the boundary

Strayer et al. 2003

Main Spatial Boundary Attributes (Structure)

- Grain
- Extent
- Thickness
- Geometry of adjacency
- Gradient (abruptness or steepness)
- Patch contrast
- Integrity (perforated vs. unbroken)
- Shape

Strayer et al. 2003

Main Spatial Boundary Attributes (Structure)

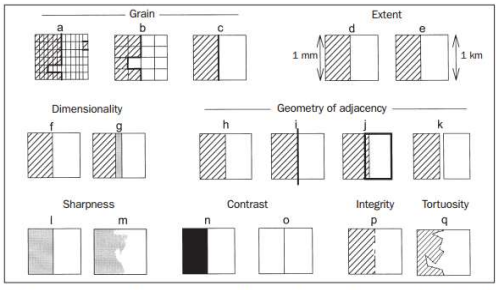
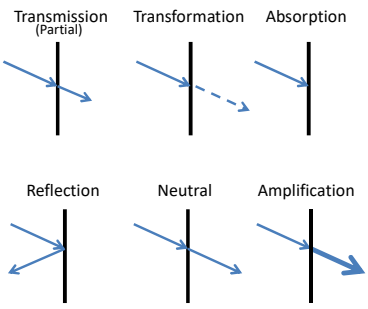


Figure 1. Some attributes of boundary spatial structure. (a) A boundary (heavy line) defined using a fine grain size; (b) the same boundary defined using a medium grain size; (c) the same boundary defined using a coarse grain size; (d) a boundary of small extent; (e) a boundary of large extent; (f) an infinitesimally thin boundary; (g) a boundary with finite thickness (the gray area is the boundary zone, which belongs to neither of the adjacent patches); (h) a boundary between two adjoining patches; (i) a boundary formed by a distinct structure (heavy line) between two patches; (j) a boundary between two overlapping patches; (k) a boundary between two disjunct patches; (l) a sharp boundary; (m) a gradual boundary; (n) a boundary between two highly contrasting patches; (o) a boundary between two slightly contrasting patches; (p) a perforated boundary; and (q) a convoluted boundary.

Boundary Function

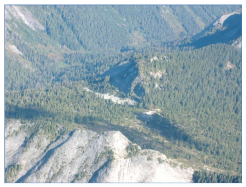
- Transmission
  (wind speed is reduced across a forest boundary)
- Transformation
  (transformation at oxic-anoxic boundaries)
- Absorption
  (the waves at the surf zone)
- Reflection
  (the approaching organism turns around, e.g. a fence)
- Neutral
  (no effect on the phenomenon at study)
- Amplification
  (increased flux at the boundary)



Strayer et al. 2003

Temporal Dynamics

- Does the boundary change in structure or function over time?
- Mobility (is the boundary stationary or moving)?
- What is the age and history of the boundary?



Strayer et al. 2003

Functional View

- Corridor = increased rate of flow relative to diffuse flow in matrix. Channelization and movement.
- Boundary = Point of Interaction between landscape patches. Regulate flux

Puth and Wilson 2001

Boundary-Corridor Continuum

- Opposite ends of permeability
- Similar conceptually
- Differ only in the direction and rates of flow
- Boundaries and corridors occupy small spatial extents relative to their large influence on ecological flows
- A linear feature can act as both a boundary and a corridor, depending on the mover or process
- Commonly manipulated by humans - therefore they should be a central consideration to managers

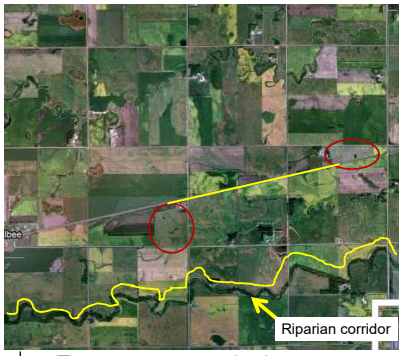
Puth and Wilson 2001

The function and dynamics of landscape corridors

Canyon grasslands, central Idaho

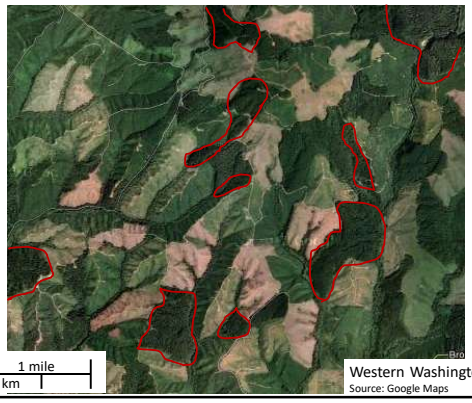
Taiga & muskeg, central Alaska

Northern Great Plains grassland, South Dakota, USA



Source: Google Maps

Forest pattern resulting from wood harvesting



Western Washington, USA

Source: Google Maps

Natural processes can also influence habitat connectivity.

Sagebrush steppe /juniper woodland mosaic, southwestern Idaho, USA

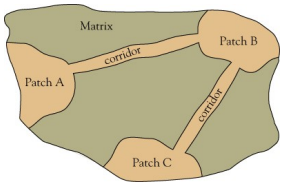
Sagebrush steppe habitat is declining reducing the amount and connectivity of habitat for sagebrush steppe obligate species.

Fragmentation has three recognized components:

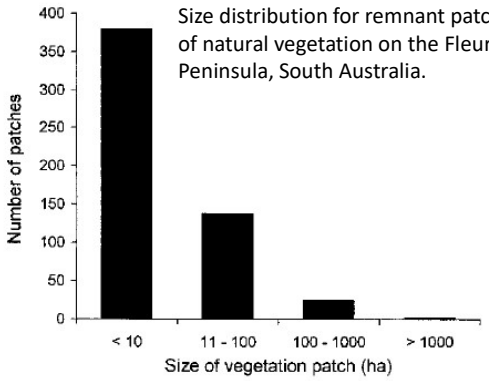
1- Habitat loss

2- Reduction in the size of patches

3- Decreased connectivity between patches (habitat isolation)



Source: Barnes 2000



Size distribution for remnant patches of natural vegetation on the Fleurieu Peninsula, South Australia.

Source: Bennett 2003

Why are small populations vulnerable to decline and extinction?

Demographic stochasticity - *random variation in population parameters such as birth rate, death rate and sex ratio.*

For example, if a small population of a short-lived species experiences, by chance, a low birth rate in two successive years, the immediate probability of survival of the population may be greatly reduced.

Genetic stochasticity - *random genetic processes that can lead to a loss of genetic variation and a reduced capacity for a population to resist recessive lethal alleles, or to respond to changing environmental conditions.*

Inbreeding depression and genetic drift can contribute to a loss of genetic variation in small populations.

Source: Bennett 2003

Why are small populations vulnerable to decline and extinction ? (continued)

Environmental stochasticity - *random variation in environmental processes that can affect a population.*

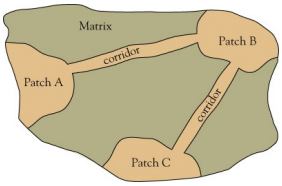
For example fluctuations in temperature, rainfall, food resources, and populations of predators and competitors.

Natural catastrophes such as floods, fire, drought, hurricanes and earthquakes, occur at irregular intervals and can have a major effect on population survival.

In fragmented environments, small isolated remnants can be totally burned and the local population of a species eliminated.

Source: Bennett 2003

Corridor terminology



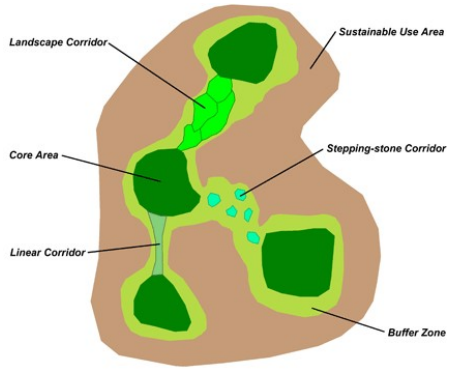
General definition: A corridor is a narrow linear strip of land that differs in structure from the surrounding matrix and facilitates movement of species and process between habitats

Similar terms: wildlife corridor, greenway, greenbelt, shelterbelt, buffer strip, landscape bridge, wildlife underpass

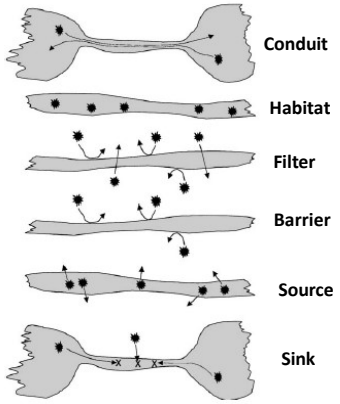
Functions can be related to:

Movement of species	**Biodiversity protection**
Gene flow	**Site recolonization of locally extinct species**
Movement of processes	
Water management	Enhancement of agroforestry production
Recreation	
Environmental modification	

Types of biodiversity corridors



Source: Asian Development Bank



Corridors may function differently within the landscape with respect to movement.

Organism, material or process

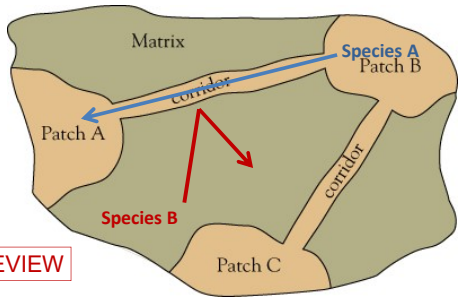
Source: Adapted from Hess & Fischer 2001

Habitat corridors are likely to be more effective means of promoting landscape connectivity:

- Where a large part of the landscape is modified and inhospitable to native species
- For species that are habitat specialists or have obligate dependence on undisturbed habitats
- For species with limited dispersal distances
- Where the goal is to maintain continuity of populations between habitats
- Where maintenance of ecosystem processes require continuous habitat for their function

Adapted from Bennett 2003

Corridors can be both conduits and barriers to the movement of species and processes

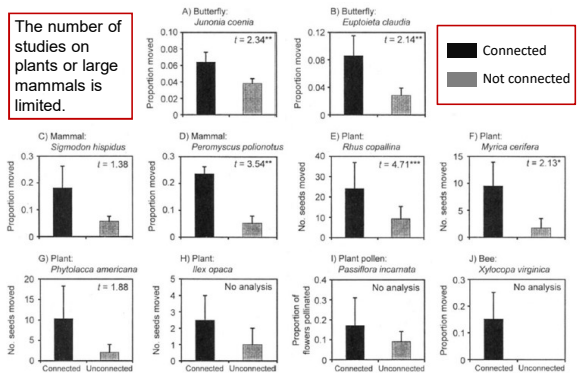


REVIEW

Source: Barnes 2000

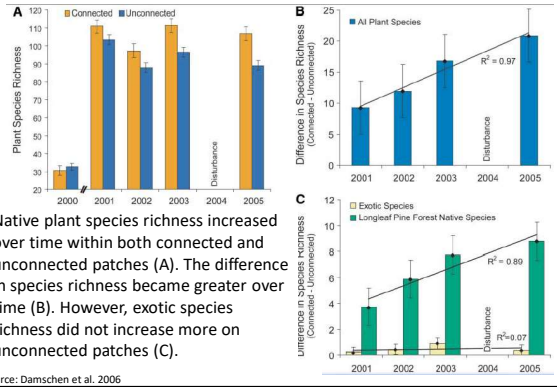
Corridors effectively increase organism dispersal

The number of studies on plants or large mammals is limited.



Source: Haddad et al. 2003

Corridors and Plant Species Richness



Native plant species richness increased over time within both connected and unconnected patches (A). The difference in species richness became greater over time (B). However, exotic species richness did not increase more on unconnected patches (C).

Source: Damschen et al. 2006

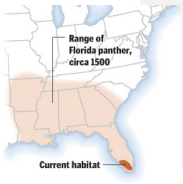
Broad-scale example: Yellowstone to Yukon Conservation Initiative

Source: Visions of the Wild

Source: Canadian Parks and Wilderness Society

Mid-scale example: Florida Wildlife Corridor

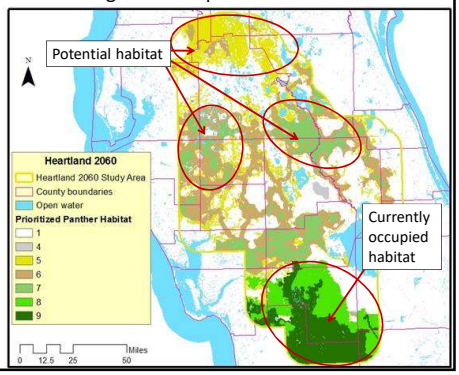
Source: SFWMD.GOV

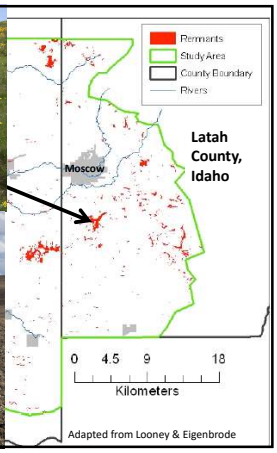


Source: The Florida Wildlife Corridor Initiative

Potential Florida panther corridor system connecting currently occupied habitat with large areas of potential habitat.

Source: The Florida Wildlife Corridor Initiative





Adapted from Looney & Eigenbrode

Landscape corridors can enhance connectivity

Landscape configuration	Fine-scale (1 -10 km)	Mid-scale (10-100s km)	Broad-scale (100-1000s km)
Habitat corridor	Hedgerows, streams, forest corridors	Rivers & associated riparian vegetation, broad linkages between reserves	Major river systems, mountain ranges
Stepping stones	Patches of native vegetation, small wetlands	Series of small reserves, woodland patches	Wetlands along flight paths, alpine habitats
Habitat mosaic	Patchy vegetation in farmland, mosaics of gardens, parks and natural areas	Mosaics of regenerating forest in forest blocks, patchy vegetation resulting from frequent disturbance	Regional mosaics supporting different vegetation communities

Adapted from Bennett 2004

Corridors may have primary objectives other than biodiversity conservation

Urban greenbelt in Boise, Idaho, USA
35 km in length, includes 12 city parks, parallels the Boise River

Corridors as fire breaks

Oak savanna, Indiana, USA
Source: Savanna Oak Foundation

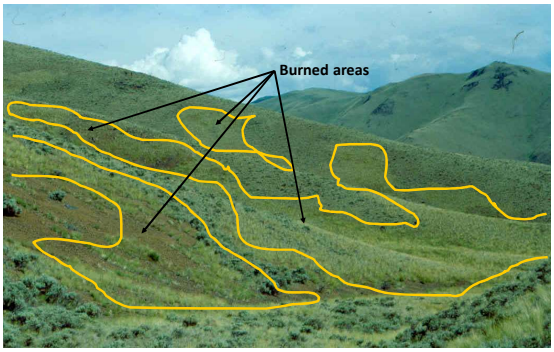
Argyll And Butte, Great Britain
Source: Geograph

Firebreaks, referred to as "green strips", have been established in sagebrush steppe to aid in fire control efforts.

Corridors as fire conduits

Riparian vegetation acts a fire conduit in arid and semi-arid areas.

Fire corridors- sagebrush steppe



Observations about functionality of landscape corridors:

- No single corridor vegetation structure serves all species equally well and some landscape patterns may actually serve as a barrier to species movement.
- The function of corridors is dynamic as landscapes change through time responding to disturbances and succession.
- Corridors may enhance the movement of invasive or otherwise undesirable species.
- The movement of wildfire within the landscape may be either enhanced or restricted by corridors.
- In some cases, landscape structure has been specifically modified to serve other purposes (e.g. fire breaks, flood zones, walkways, greenbelts) and may or may not be effective as biological corridors. In some cases minor modifications can make them more effective biological corridors.

Landscape Ecol (2015) 30:21–50
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REVIEW ARTICLE

What can studies of woodland fragmentation and creation tell us about ecological networks? A literature review and synthesis

Jonathan W. Humphrey · Kevin Watts · Elisa Fuentes-Montemayor · Nicholas A. Macgregor · Andrew J. Peace · Kirsty J. Park

Synthesised 104 studies, published 1990- 2013

- Development of ecological networks could help reverse the effects of habitat fragmentation on woodland biodiversity in temperate agricultural landscapes.
- Improving or expanding existing habitat patches is more effective compared to landscape-scale rehabilitation (e.g. creating new habitat or corridors in the landscape).
- Species responses (richness, diversity, occurrence) were strongly influenced by patch area, patch characteristics (e.g. stand structure) and isolation (e.g. distance between habitat patches).
- Very few studies have assessed all local and landscape variables together. Further information on impacts of different attributes of ecological networks in temperate agricultural landscapes is urgently needed.

Considerations in the design and management of conservation corridors

Biological issues

- Biological purpose
- Behavior and ecology of species
- Structural connectivity
- Quality of surrounding habitat
- Quality of corridor
- Corridor width and edge effects
- Location
- Monitoring capability

Socio-political issues

- Status and tenure of land
- Management responsibility
- Adequacy of resources
- Support from local communities
- Integration with other land management programs
- Community education and awareness
- Strategic approach to planning
- Most efficient use of conservation funds

Adapted from Bennett 2003