



A rule of thumb for widths of conservation corridors

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Introduction

A conservation corridor is a continuous swath of relatively natural land between natural landscape blocks (e.g., protected areas) identified for conservation to support gene flow and demographic interactions between the linked blocks after build out, that is, after lands surrounding the corridor and natural blocks (*matrix* hereafter) have been converted to urban, agricultural, or industrial uses incompatible with wildlife movement (Beier & Gregory 2012). Thus, a corridor is one of several conservation interventions (the others being steppingstones, protected-area expansion, and managing the entire matrix for permeability) that can be used to achieve the conservation goal of connectivity (Beier et al. 2008; Gregory & Beier 2014); it is synonymous with “landscape linkage” sensu Bennett (1999:10). In largely intact landscapes where the matrix is publicly or communally owned, managing the entire matrix for permeability may be a better conservation intervention than a corridor. But corridors are the primary conservation intervention in landscapes where the matrix is being actively converted to human uses.

Where the blocks to be connected are separated by only a highway, canal, or railroad, a wildlife-crossing structure may serve as a conservation corridor (Clevenger & Huijser 2009). This essay considers the larger scale problem of designing corridors to connect blocks up to 80 km apart in a matrix threatened by conversion to land uses that impede wildlife movement.

Over 200 corridor designs, ranging in length from 1 to 200 km, have been proposed in ≥ 30 countries on all 6 human-populated continents (A. Keeley, University California Berkeley). For these designs, there are many scientific approaches and empirical data to identify optimal routes under current conditions (Rudnick et al. 2012; Cushman et al. 2013) or under climate change (Beier

2012). But there is a shocking lack of rigorous scientific evidence to address the question of how wide the corridor along that optimal route must be to meet conservation objectives. Indeed, recent reviews of fragmentation and corridors either failed to mention corridor width (Haddad et al. 2015; Abrahms et al. 2017; Resasco et al. 2017) or bemoaned the lack of empirical evidence and pointed out that corridor width is the unknown quantity most urgently needed by land managers (Gilbert-Norton et al. 2010; Haddad et al. 2011; Sawyer et al. 2011).

A rigorous approach to assess the effectiveness of landscape corridors is available (Gregory & Beier 2014), but to date only 3 studies have used this design to assess corridor effectiveness (Mech & Hallett 2001; Horskins et al. 2006; Sharma et al. 2013), none of which reported width of the corridor. It will probably take decades to evaluate enough corridors, with replication across a broad spectrum of corridor widths, so that a meta-analysis can address the question of how wide a corridor should be to provide long-term gene flow and recolonization. Until then, practitioners would benefit from a rule of thumb—an easily learned, easily applied, and relatively inexpensive standard—derived from practical experience and reasonable inference based on knowledge of related issues.

Rule of Thumb

A corridor should be at least 2 km wide, except at unavoidable bottlenecks such as highway crossing structures.

Precautionary Framing of the Question

Over the past 30 years, the question of minimum corridor width is—by far—the question I have been most frequently asked by wildlife advocates concerned about

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a project that provides a narrow corridor, project proponents who assume a width of 10 m should suffice, and land-use planners trying to reach a fair compromise. The question should not be posed as how narrow a corridor the focal species might use. This is analogous to asking an engineer, what are the fewest number of rivets that might keep this wing on the airplane? Planners should reframe the question as, what is the narrowest corridor width that is not likely to be regretted after the adjacent area is converted to human uses (Beier et al. 2008)? If a corridor design is too narrow, implementing that design would waste the conservation investment. One obvious way to minimize this risk is to demand that corridors be as wide as the natural blocks to be connected. However, such a recommendation would be prohibitively expensive (and thus irrelevant) and would more honestly be characterized as expanding (rather than connecting) the protected areas. Framing the question in this precautionary way can minimize the risk of failure while recognizing practical constraints.

Accommodating Corridor Dwellers

Beier and Loe (1992) categorized corridor users into 2 groups based on their mobility relative to corridor length. Passage species are species in which an individual animal can walk the length of the corridor in a single event of a few hours or days. In contrast, corridor dwellers need more than a generation to move individuals or genes from one patch, through the corridor, and into the other patch. For corridor dwellers, the corridor should be wide enough to accommodate overlapping home ranges along most of its width so that animals can reside, find mates, and produce offspring that can disperse in the corridor. Although width of home range is unknown for most animals, a reasonable estimate can be made from area of home range by assuming home range is a rectangle that is twice as long as it is wide (Harrison 1992). A corridor 2 km wide would accommodate home ranges of up to about 8 km², which is larger than home ranges of 96% of terrestrial mammal species likely to be corridor dwellers (Fig. 1).

Edge Effects

Edge effects arise from artificial night lighting, noise, chemical pollution (especially important for aquatic linkages), nest predation, nest parasitism, invasive species, and other disturbances that can intrude into a corridor from adjacent human-dominated land. In North America, negative edge effects are biologically significant at distances of up to 300 m (25 studies summarized by Environmental Law Institute [2003]). Thus, unless active management diminished edge effects, a corridor 600 m wide would have no area free of edge effects. A corridor 2 km wide would have at least 1400 m free of edge

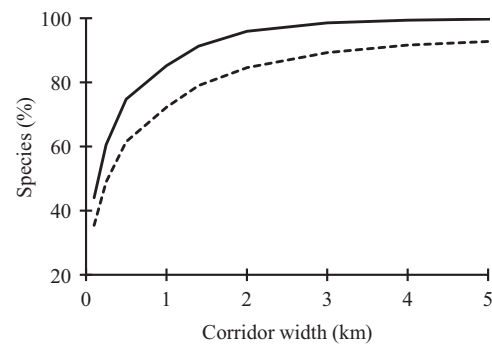


Figure 1. Percentage of terrestrial mammal species whose home-range (HR) widths calculated as $(HR \text{ area}/2)^{1/2}$ (Harrison 1992) (areas of home ranges from Tucker et al. [2014]) fit in a corridor of a given width (dashed line, all 429 terrestrial mammals listed by Tucker et al. [2014]; solid line, 345 probable corridor-dwelling mammals selected by excluding 84 large [> 10 kg] ungulates, carnivores, and herbivorous marsupials because they are probably passage species in most corridors).

effects, a width that could accommodate home ranges of about 91% of mammalian corridor dwellers (Fig. 1).

Recreational Use

Because corridor proposals need political support and because unregulated human recreation may impede animal movement, most corridor designs include plans for regulated recreation. A wide corridor can include trails strategically located to leave parts of the corridor relatively free from human disturbance. Although this consideration may not require a particular minimum width, it provides a reason not to compromise on width.

Utility for Species Not Used to Inform the Location of the Corridor

Another reason not to compromise on a 2-km minimum width is that wide linkages are more likely to include diverse conditions (vegetation, topography, and soil) that will serve diverse species, including species that were not used to inform the design of the corridor (Brost & Beier 2012), and help plants and animals shift their ranges in response to climate change (Beier 2012).

Modifications

Existing human infrastructure or water bodies may create bottlenecks narrower than 2 km. For example, where a corridor is crossed by a highway or canal, its width at that location is the summed widths of the wildlife crossing structures. I suggest such bottlenecks should sum to no

more than 10% of corridor length and should be mitigated by widening other parts of the corridor.

In landscapes where unrestorable barriers preclude a width of 2 km, I recommend conserving the widest possible corridor and learning from the experiment by monitoring gene flow as a measure of efficacy of the narrower corridor (Gregory & Beier 2014).

The 2-km rule of thumb reflects my experience designing corridors to connect habitat blocks 8–80 km apart, each at least 50 km² in size. If the rule is extrapolated to other settings, the following adjustments, for example, may be needed. A corridor >80 km long may need to include 1 or more large habitat patches, where animals could reside for a few weeks or where climate migrants could build up enough propagule pressure to maintain flow through the corridor. For habitat blocks significantly smaller than 50 km², the 2-km rule could produce a corridor several times larger than the habitat blocks to be connected. In this case, a width < 2 km may be appropriate, or the effort may better be described and justified as expansion of a protected area rather than as a corridor. As corridor length decreases below 8 km, an increasingly large proportion of animals will be able to travel the corridor in a single dispersal event without needing a live-in corridor, thus permitting some relaxation of this rule.

In landscapes that lack native land mammals (e.g., New Zealand), the size of home ranges of reptiles, amphibians, and sedentary birds could be used to develop a different (likely narrower) minimum width.

The 2-km rule of thumb is intended to complement procedures used to identify an optimal route for a corridor. I welcome the day when a rigorous meta-analysis of empirical studies (Beier & Gregory 2012) renders this rule of thumb obsolete.

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