Action: Creating Corridors that do not Aid the Invasion of Exotic Species

Key Messages

- Two studies at the Savannah River Site Corridor in South Carolina and literature review including 17 papers that were located at the same study site, six of which focused on invasion, found that the benefits of biological corridors outweigh the potential negative effect of increasing invasion by exotic species.
- A literature review assessing the various negative effects of corridors as well as an empirical study conducted at the Savannah River Site found that edge effects, not invasion, are of more concern when building corridors.
- A study on invasive cane toads in Australia found that a simple way to prevent corridors being used for invasion is to leave areas more vegetated. Additionally, a study focusing on hedgerows as possible modes for invasion found that they instead have the potential to block invasion if constructed properly.
- Two studies in Australia found that invasive cane toads are utilizing habitat corridors for dispersal, one through roads and one through overpasses and culverts.

Background Information

Habitat fragmentation is considered to be one of the most pressing threats to biodiversity (Damschen et al., 2006). As natural habitats continue to become fragmented and more isolated, many important species are facing dramatic and dangerous habitat loss (Wilcove et al., 1998). Biological corridors are an extremely popular way to try and combat this fragmentation (Damschen et al., 2006). The purpose of corridors is to connect isolated patches of habitat, allowing populations to move between locations. Linkages increase habitat size, gene flow, and resource availability. In some cases, corridors are so effective that they can increase movement between habitat patches by 50% compared to the rates of movement between isolated patches (Gilbert-Norton et al., 2010). A 1998 paper by Beier & Noss (1998) describes corridors as a tool to retain the natural connectivity landscapes tended to have before anthropogenic alterations and influence. Corridors are considered a valuable conservation tool because the consensus among the majority of researchers is that connected landscapes are preferable to unconnected ones (Beier & Noss, 1998).

Despite their popularity, corridors may have potential costs, both ecological and economic (Simberloff & Cox, 1987). Simberloff (1992) noted the weak theoretical and empirical basis for many corridors, and his previous papers identified the failings of the current literature in considering the potential negative consequences of biological corridors (Simberloff & Cox, 1987). While empirical data on corridors tends to be lacking, relying more heavily on observational data, the empirical studies that do exist have either been conducted on a small scale or ignored confounding effects (Tewksbury et al., 2002). One major potential consequence of corridors is their possible role in increasing the dispersal rates of invasive species. Invasive species cause enormous amounts of environmental and ecological damage (Mack et al., 2000;

Pimentel et al., 2000; Wilcove et al., 1998). This includes disrupting nutrient cycling, outcompeting native species for resources, heavy predation, and diminishing the overall biodiversity (Mack et al., 2000). A study by Pimentel et al. (2000) estimated that $137 billion in environmental damages per year are caused by the 50,000 non-native species in the United States. While little research has been done on the topic, there are a few studies that aim to quantify and evaluate the role of biological corridors in promoting the movement of exotic species. With the potential for such devastating environmental impacts, it is important to examine the relationship between corridors and invasive species to inform the future construction of biological corridors as tools for conservation.

Supporting Evidence from Individual Studies

1. A study conducted at the Savannah River Site Corridor in South Carolina measured the effects of connectivity and the facilitation of wind-dispersed plant pathogens (Johnson & Haddad, 2011). The study site consisted of 8 experimental landscapes, each one divided into five 1 ha habitat patches (winged (50% more edge) and rectangular) connected by 25 m wide corridors. The study involved 3 experiments using sweet corn (*Zea mays*) and southern corn leaf blight (*Cochliobolus heterostrophus*) as the plant-pathogen model system. The first experiment found that patch shape has a marginally significant effect on the proportion of diseased plants. This was determined by inoculating plants in the center of the patches and collecting data on the number of diseased plants across four time intervals. In the second experiment, all plants were placed equidistant from habitat edges and weren't in the field as long. Tissue samples of the plants were incubated and analyzed. By controlling for all environmental conditions aside from connectivity, patch shape was shown to have had no effect on where spores landed. The final experiment assessed the effects of patch shape and distance to edge on disease development. All plants were equally inoculated. After 6 days, 10 cm sections on the plants were analyzed to determine disease development. Researchers found that in rectangular patches, initial disease levels differed while final levels did not. Plants 40 m from the edge in rectangular patches had higher disease development than those 0 m from the edge, representing a total 35% increase overall. For winged patches, disease development was greatest at an intermediate distance of 20 m. The study shows that connectivity does not increase the level of disease, and that the patch shape had more of an effect on disease development. Also, the distance to the edge had an effect on disease development; in both types of patches more core habitat areas were linked to less disease.
2. A study at the Savannah River Site Corridor in South Carolina measured the effects of corridors on the dispersal behavior of two social forms of invasive fire ants (*Solenopsis invicta)* and their effects on native ants (Resasco J. et al, 2014). Researchers gathered initial data by sampling native ants using pitfall traps laid in transects. As a second measure of fire ant abundance, researchers counted mature and active nests throughout the study. 10,775 ants of 49 species were collected, fire ants were found to make up

99.8% of non-native ants and 68% of all ants. The social form had a strong effect on fire ant density; pitfall traps from polygyne-dominated areas contained more than 10 times as many individuals than those of monogyne blocks. Corridors were found to have significantly increased the abundance of polygyne, but not monogyne, fire ants. This is supported by the lower species diversity in pitfall traps located in connected polygyne fire ant dominated corridors. Results indicated that the effect of corridors in ant communities are in large part determined by the variation in dispersal ability and population density associated with an invasive colony's social form. However, despite the negative effect on species diversity, evidence favors the beneficial effects of corridors in conservation.

3. Researchers conducted a study at an invasion front in the northern territory of Australia (Brown et al., 2006). A 9 km stretch of dirt road and tracks was surveyed for 320 nights in order to determine if the invasive Cane Toad (*Bufo marinus*) used certain features along the road like cleared fence lines, vegetation strips, or the road itself as an invasional corridor. 49 adult toads were fixed with radio transmitters to track movement and the angle of which they traveled down the roads. Spotlighting from a slow-moving vehicle was used to estimate the number of toads on the road. Finally, the last part of the study, which tested for locomotor speed, placed the toads inside two concentric rings. After encouraging the toad to begin moving, researchers recorded the time and number of hops required to move from one ring to the other. Results showed that toads actively select for open habitats in which to travel. The radio-tracked animals' movement was consistent with roads so much so that in some cases toads moved in 90-degree angles to keep with the road. This is likely because it is more energy efficient for toads to travel that way. The locomotor speed tests show that toads moved faster between the rings on the road substrate versus the vegetation. The study confirmed that isolated patches of habitat surrounded by vegetation may be relatively safe from cane toad invasion as they are not connected to open corridors. Therefore, it is possible to block toads from entering areas by minimizing the numbers of clearings and blocking paths with fences too high for toad but low enough to allow passage by other species.
4. A study in California's central valley aimed to determine if hedgerows have the potential to host nonnative species (Wilkerson, 2014). The study area (1400 km) consists of agricultural fields, rangeland, and a high number of hedgerows. 31 hedgerows were selected based on similar management methods, diversity of ages, and if they were planted as native species for the study (15 of which were used in the shade experiment). Hedgerows ranged from 2-7 m in width and 120-800 m in length. The hedgerows had generally the same planted species: *Sambucus nigra*, *Heteromeles arbutifolia*, *Cercis occidentalis*, *Baccharis pilularis*, *Ceanothus* spp., *Quercus lobata, Stipa pulchra*, *Elymus glaucus*, *Elymus triticoides*, and *Muhlenbergia rigens*. In order to record observational data on native and invasive species, larger hedgerows were divided into 15 transects while only 5 were used for smaller ones. In total, 106 herbaceous species were identified

with 63% being non-native. 82% of species richness consisted of invasive plants, most of which are associated with California's agricultural system. Edges of the hedgerows have 24.5% higher invasive species richness. To complement this data a shading study was performed. Mesh cloths mimicking 90%, 60%, and 30% light blockage were placed in hedgerows. Results indicate that 30% shade increased the diversity and cover of non-native species while 90% and 60% decreased it. The study shows that increased shade had a significant negative effect on invasive plants and that invasive plant diversity and abundance decreased significantly in hedgerow interiors despite the narrowness of some hedgerows. The paper suggests that hedgerows can actually be used as barriers to plant invasions if their structure resembles that of the interior. Suggested ways to mimic this include using fast-growing native shrub species or creating double rows.

5. A 2014 literature review aimed to find evidence that corridors increase unwanted disturbance or non-native species invasion (Haddad et al., 2014). While studies and literature in this area were lacking, 26 papers fit guidelines and 6 of these addressed the issue of invasive species. The Savannah River Site Corridor was the study site for 17 of the papers. The paper search guidelines were restricted to peer-reviewed journals and empirical studies with main search terms corridor, ecol*, conserv*. Additional terms inva* and exotic* were added for invasive species based papers specifically. Studies that looked at the abundance of invasive species in corridors without comparing them to another connected or unconnected corridor were not included, nor were studies that speculated about corridor use based on observations of animal behavior. In addition, studies looking at increased connectivity through sources other than corridors, or ones that dealt with only unconnected patches were discarded from the review. The number of studies collected on invasion specifically was not enough to call for meta-analysis. None of the 6 papers on invasion found evidence of a negative effect of corridors. The literature review as a whole identified the creation of an edge as the only type of corridor to increase invasion. The existing evidence shows that the potential costs of corridors are outweighed by the conservation benefits, however more larger-scale studies are needed.
6. To mitigate the effects of the widening of a road from two to four lanes, two underpasses and one overpass were constructed in Brisbane Australia. (McGregor, 2016). The road bisects the Karawatha Forest and Kuraby Bushland nature reserves. A study investigated the extent to which reptiles and amphibians used the corridors. Pitfall trapping and 15 minute observational hand searches were conducted during each trapping season. In total, 343 individuals across 29 species were identified to be using corridors. Of these 29 species, two were invasive: The Asian house gecko (*Hemidactylus frenatus*) and cane toads (*Rhinella marina*). The cane toads were the most reliably captured species on the overpass, indicating that it is likely using it as a dispersal pathway.

Conclusions and Recommendations

While the literature surrounding the effect of corridors on invasive species is lacking, the few studies that do exist tend to share the same view that the benefits of corridors for conservation largely outweigh the potential negative effects of invasion. Although corridors may slightly increase the level of invasion for certain species, it is not enough to be considered a major concern as these species have the potential to invade with or without the presence of a corridor. Instead, the greater and more supported concern over negative corridor effects lies in the creation of edges and their accompanying effects. It is critical to use our substantial knowledge of the behavior of potentially invasive species when building corridors as the dispersal behavior of some species may be better-suited to invasion than others. Additionally, this knowledge can help the construction of corridor elements, like fences and hedgerows, that can mitigate potential invasions. Going forward, more empirical and large-scale studies are required in order to more completely support the statement that corridors do not support the spread of non-native species.

Supporting Studies

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