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Action: Creating corridors to influence plant dispersal

Background Information

Habitat fragmentation greatly threatens global biodiversity, by limiting population sizes of species, and restricting gene flow between populations (Kirchner et al., 2003). This results in a reduction in genetic diversity in populations, and increases their susceptibility to local extirpation. Corridor creation is a direct and popular method for mitigating the negative effects of habitat fragmentation, and restoring habitat connectivity (Haddad et al., 2014) and (Evans et al., 2012). Corridors are expected to increase the likelihood of a species' survival within fragmented landscapes, by increasing gene flow between populations (Kirchner et al., 2003).

However, empirical evidence on the efficacy of corridor creation is lacking (Tewksbury et al., 2002) and (Kirchner et al., 2003). This holds true especially for the effects of corridors on plant dispersal. Few studies have examined the effects of corridors on plants, largely because of the difficulties inherent in studying the effects of corridors on sedentary organisms (Evans et al., 2012) and (Tikka et al., 2001). Out of the studies which have been conducted, several have demonstrated that corridors may benefit plants by increasing pollen and seed dispersal (Evans et al., 2012). However, corridors may also fail to benefit dispersal and populations (Tikka et al., 2001). In addition, corridor creation could have negative effects on plant populations. For example, studies have reported invasions of exotic species through corridors (Tikka et al., 2001).

The effect of corridors on plant dispersal is important to understand, because the persistence of existing plant populations, and the recolonization of plants to disturbed areas within fragmented landscapes, is largely determined by gene flow through pollen and seed dispersal (Tewksbury et al., 2002). Therefore, plant dispersal is important recovery of fragmented habitats.

Key Messages

- Studies analyzing the effect of corridors on plant dispersal were used for this paper.
- A study by Kirchner et al. found that flooded natural corridors have been shown to increase seed dispersal and gene flow between plant populations, and connection among habitats.
- A study by Tewksbury et al. in the Savannah River site found that corridors facilitate animal mediated pollen and seed dispersal, and this effect may be widespread among plant species. A study by Damschen et al. in the Savannah River site found that corridors have been found to increase diversity of native plants, and not increase diversity or number of exotic species. A study by Townsend and Levey in the same site found that corridors increase insect (butterfly, bee, and wasp) mediated pollen transfer.
- A study by Kormann et al. found that tropical forest corridors likely increase hummingbird mediated pollen dispersal

Supporting Evidence From Individual Studies

1. *Role of Corridors in Plant Dispersal: an Example with the Endangered Ranunculus nodiflorus* - (Kirchner et al., 2003)

A study from 1999-2000 in the Fontainebleau forest of France found that corridors have a strong influence on gene flow between populations of *Ranunculus nodiflorus* L, due to the effect of corridors on seed dispersal between populations. The study additionally indicated that connection between populations can play a role in plant dispersal. To analyze the role of corridors in seed dispersal, the researchers studied the population genetic and demographic structure of metapopulations with spatially and temporally varying numbers of component populations in four sites. The metapopulations consisted of matrices of connected and isolated ponds, ranging from 1 – 2250 m^2 in size, arranged within an area of 1 hectare or less. The ponds were considered suitable habitat for the species, and the ponds containing *R. nodiflorus* L. individuals were considered populations. Natural corridors formed the connections between ponds, and were narrow patches of land (a few tens of centimeters wide) devoid of vegetation. Connections between the ponds were formed after rainfall, when the corridors flooded. The analysis of genetic structure was conducted by performing AMOVA analyses on genetic samples taken from individuals within 44 of the populations. The observed genetic analysis indicated that corridors have a strong influence on gene flow between populations, because genetic differentiation between two populations was strongly influenced by the presence or absence of a corridor between them ($p < 0.005$). The demographic results indicated that corridors provide gene flow between populations by increasing seed dispersal.

2. *Corridors affect plants, animals, and their interactions in fragmented landscapes* - (Tewksbury et al., 2002)

A study from 1999-2000 in South Carolina found that corridors can substantially facilitate pollen and seed dispersal, due to the activities of a wide variety of animals. Eight large-scale (50 hectare) experimental landscapes composed of mature forest were selected in the Savannah River site. The researchers compared movement rates of animal-dispersed pollen and seeds from 1-ha central patches within the landscape, to four peripheral patches within the landscape. 25-m wide corridors connected each main patch to one of the peripheral patches. The deciduous holly (*Ilex verticillata*) was used to measure the influence of corridors on pollen dispersal. The yaupon holly (*Ilex vomitoria*) and the wax myrtle (*Myrica cerifera*) were used to measure the effects of corridors on seed dispersal. Fluorescent powder was sprayed onto all *M. cerifera* fruits within the central patches, so that fruits from those patches could be identified. The study found that the chance of finding *I. vomitoria* seeds was over two times greater in connected patches than unconnected patches, which indicated that there is greater dispersal of the seeds between connected patches than between unconnected patches. The study also found a significantly greater proportion of fluorescent power in animal fecal samples in connected patches than non-connected patches (18% increase from non-connected to connected patches), indicating that there is greater animal mediated seed dispersal of *M. cerifera* seeds between connected patches than non-connected patches. This result showed an effect of corridors on bird-mediated seed dispersal. The study found that fruit set was greater in patches connected by corridors than unconnected patches (69% greater in connected patches than unconnected patches). Fruit set was a function of pollen dispersal, so this indicated that pollen dispersal was greater between connected than non-connected patches.

The increases in pollen movement and seed dispersal occurred due to a wide variety of animals. The authors argued that as a result of this, the beneficial impact of corridors on animal-mediated pollen and seed dispersal may be relatively widespread among plants.

3. *Corridors Increase Plant Species Richness at Large Scales* - Damschen et al., 2006

A large-scale replicated experiment conducted from 2000-2005 in South Carolina found that higher native plant diversity is supported in habitat patches connected by corridors than in isolated patches. The study further demonstrated that the difference in species richness between unconnected and connected habitat patches increases over time, and the corridors do not increase invasion by exotic species. Six 50-hectare landscapes were selected in the Savannah River site to study the effect of corridors on native plant species richness. The landscapes contained habitat patches connected by corridors and isolated habitat patches. The patches consisted of open habitats of native longleaf pines and abundant herbaceous understories, and the matrix consisted of dense pine plantations. The connected patches were linked by corridors with lengths of 150m, and widths of 25m. The researchers found no detectable difference in number of species between isolated and connected patches at the beginning of the study, but connected patches contained 20% more species than isolated patches by the end of the study. The researchers hypothesized that corridors benefit native species richness through avenues such as increasing seed deposition, increasing pollen movement, and altering species predator behavior in ways that prevent competitive exclusion. The study found that corridors had no detectable effect on number of exotic species, and therefore did benefit richness of exotic species.

4. *AN EXPERIMENTAL TEST OF WHETHER HABITAT CORRIDORS AFFECT POLLEN TRANSFER* – Townsend and Levey, 2005

A large-scale study in South Carolina in 2000-2001 found results indicating that corridors increase butterfly, wasp, and bee mediated pollen transfer between patches of habitat in fragmented landscapes. The experiment was conducted at the Savannah River Site, in mature (>40 year old) forest dominated by Slash Pine (*Pinus elliotii*) and Loblolly Pine (*Pinus taeda*). Patches were created within the ecosystem by harvesting trees. Eight experimental units were created. Each experimental unit contained a central patch, and four peripheral patches. 25m wide corridors connected one of the peripheral patches to the central patch within each unit. *Latana camara* and *Rudbeckia hirta* were the plants selected for the study. The study found that butterfly-mediated pollen transfer was greater between connected patches of habitat than isolated patches of habitat. 59% ± 9.2% of flowers received pollen in connected patches, vs. 25% ± 5.2% of flowers received pollen in unconnected patches. It also found significantly higher pollen dispersal as a result of bees and wasps in connected patches than in unconnected patches. 30% ± 4.2% of flowers received pollen in connected patches vs. 14.5% ± 2.2% of flowers received pollen in non-connected patches. The researchers hypothesize that the pattern of pollen transfer occurred because the pollinators disperse by corridor and matrix, but prefer corridors.

5. *Corridors restore animal-mediated pollination in fragmented tropical forest landscapes* – Kormann et al., 2016

A study conducted in Southern Costa Rica in 2013 found that corridors increase hummingbird-mediated pollen dispersal. The study analyzed whether presence of corridors benefit animal mediated pollen dispersal in the area near the Las Cruces biological station, which was characterized by humid tropical forest. To do this, the study tested whether pollen flow is greater between neighboring forest fragments when they are connected by a corridor, than when they are unconnected. Historical deforestation had created the fragments analyzed in the study. A pollen tracking experiment was established in 14 replicated landscapes, each of which included two forest fragments surrounded by a pasture. The corridor between the two forest fragments consisted of a wooded fencerow, ranging in length from 40m to 120m. Fluorescent dye was utilized to track pollen movement among artificial flowers placed in the forest fragments. The study additionally assessed pollination in natural stands of *H. tortuosa* with differing connectivity. The results indicated that corridor presence strongly increases pollen transfer through highly modified farmland.

Conclusions and Recommendations

Influence of corridors on plant dispersal:

Among the research papers I analyzed, there was a consensus that corridor existence benefits plant dispersal. In addition, the papers did not find evidence supporting any of the predicted negative effects of corridor creation. Although the research papers covered a limited set of species, the predicted and determined mechanisms through which corridors benefit the analyzed plant species seem as though they would hold true for most species. For example, I assume that increased animal movement as a result of corridor creation would increase dispersal of most animal dispersed plants. As a result, I conclude that corridor creation would likely benefit the dispersal and population persistence of most plant species. In addition, I conclude that corridor creation likely does not pose a risk of negative effects.

Caveats:

There appears to be a lack of literature concerning the effects of reforested tropical forest corridors on plant species dispersal. I determined this, because almost all of the research papers the Big Cat Initiative class and I were able to find on the effects of corridors on plant dispersal were in temperate ecosystems. I find this concerning, because it might decrease the relevance of these findings to the tropical forest corridor creation projects being undertaken by Saving Species. I find also find it concerning the majority of papers we found on the topic used the same study site (Savannah River site in South Carolina). It is possible that the benefits of corridor presence at that specific site would not hold true for other ecosystem types, because the efficacy of corridors can vary greatly among systems (Levey et al., 2005). I additionally find it concerning that corridors were created at that site by clearing trees, rather than planting them. This further might decrease the relevance of the findings.

Recommendations:

I find it likely that creation of tropical forest corridors through reforestation would improve plant dispersal in tropical forest ecosystems. However, research needs to be conducted on the

effect of reforested tropical corridors on plant dispersal. I recommend that Saving Nature continue corridor construction. I also recommend that Saving Nature look into opportunities to fund research on determining how to best improve plant dispersal through corridor creation in tropical forests, if possible.

Supporting Studies

1. Kirchner, F., Ferdy, J.-B., Andalo, C., Colas, B., & Moret, J. (2003). Role of Corridors in Plant Dispersal: An Example with the Endangered Ranunculus nodif lorus. *Conservation Biology*, *17*(2), 401–410. https://doi.org/10.1046/j.1523-1739.2003.01392.x
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4. AN EXPERIMENTAL TEST OF WHETHER HABITAT CORRIDORS AFFECT POLLEN TRANSFER - Townsend—2005—Ecology—Wiley Online Library. (n.d.). Retrieved December 5, 2019, from https://esajournals-onlinelibrary-wiley-com.proxy.lib.duke.edu/doi/full/10.1890/03-0607
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