Action: Creating corridors to influence biodiversity

Key Messages:

- A total of six studies from across the world were summarized in this document. One of them is based on urban gardens, one of them was based on in-door moss micro-ecosystem, and the rest four were based on natural corridors.
- All six of them support that creating corridors or maintain existing corridors have positive influences on biodiversity. Corridors can help habitat patches contain relatively higher species richness, abundance, and slow down the rate of local extinction.
- The width and the vegetation composition of the corridors are important to the communication function of the corridors.
- In a long corridor, the end near to the "mainland" has more "mainland" species and high abundance than the far end.
- The response of different species taxa to the same corridors can be different.

Background Information

Because of human activities, the current extinction rate of species is about 1000 times faster than the background rate of extinction [1]. Habitat loss and habitat fragmentation caused by humans are the major contributors to this acceleration [2]. According to the theory of island biogeography, each fragmented habitat is like a small island, and its local extinction rate depends on its size and its distance to other habitat patches or "mainland" [3]. Thus many conservation ecologists suspect that using corridors to connect habitat patches or connect isolated patches to continuous habitats can be an effective way to enlarge the size of habitat patch and to facilitate its connection with other habitat patches and therefore lead to positive biodiversity impacts, for example, maintain relatively high species richness and abundance.

However, few conservation corridors have been established yet, and few studies have quantified the biodiversity impacts of habitat corridors [4]. In this document, six peer-reviewed articles about quantifying the impacts of corridors on species richness and abundance were summarized. One of them is based on urban gardens, one of them was based on in-door moss micro-ecosystem, and the rest four were based on natural corridors. Nature corridors are the habitat strips that were left on changed landscapes and connect at least two habitat patches. All the six studies provide empirical support that creating corridors or maintain existing corridors have positive influence on maintaining species richness or abundance. The three studies done in Brazil Amazon also provide insights about the impacts of corridors on different taxa and what factors influence the effect of corridors. The two main influence factors mentioned are the width of corridor and the vegetation quality of the corridors.

Reference

1. Pimm, S.L., et al., The biodiversity of species and their rates of extinction, distribution, and protection. 2014. 344(6187): p. 1246752.

2. Myers, N., et al., Biodiversity hotspots for conservation priorities. 2000. 403(6772): p. 853.

3. MacArthur, R. and E.O. Wilson, The Theory of Island Biogeography. 1967.

4. Gilbert-Norton, L., et al., A meta-analytic review of corridor effectiveness. Conservation biology, 2010. 24(3): p. 660-668.

Supporting Evidence from Individual Studies

1. A replicated, controlled study in the urban gardens in around 2010 in Paris, France [1], found that the abundance of staphylinids and spiders in gardens that are connected wood corridors are significantly higher than the gardens that are not connected to wood corridors. On average, 11.16 staphylinids and 10.96 siders were found in each connected garden, while only 3.87 staphylinids and 6.5 spiders were found in each disconnected garden. The not connected gardens also have significantly lower species richness of staphylinids. On average, 3.32 species of staphylinids were found in each connected garden, while only 1.29 species were found in each not connected garden. The wood corridor not only linked the isolated gardens together but also connected them with an urban woodlot (park or wood up to 150 ha) in each study site. All the arthropods were sampled with pitfall traps.

2. A replicated, controlled study using moss patches as study subjects to explore the effects of corridors in reducing the rate of losing species [2]. The study was conducted in October-November 1995, and the moss micro ecosystems were put on bare rocks to mimic the environment that is relatively inhospitable for the majority of moss taxa. Four different types of treatments were studied: a. mainland (four circular samples taken from the surrounding matrix of continuous moss), b. corridor (four islands connected along the sides of the square by corridors), c. broken corridor (as the corridor treatment, but corridors split in the middle and separated by a gap) and (iv) insular (no corridors present). In three months, comparing to the continuous moss (the mainland treatment), islands with corridors lost an average of 15.5% of their species, whereas the disconnected islands (broken + island treatments) lost almost 41%.

3. A replicated, controlled study in remnant riparian forests in May-October 2005 in Mato Grosso, Brazil [3]. 37 riparian forest sites were studied (including 24 corridors connected to large forest patches, 8 unconnected forest corridors, and 5 control riparian zones embedded within continues forest patches). Both bird and mammal were surveyed. Bird survey used point-counting, while mammal survey used track-sampling. In total, 17999 detections of 365 bird species were recorded during 444 point counts. The mean species richness of continuous forest zones was 141.1, the mean species richness of connected corridors was 100.70, while the mean species richness of the unconnected corridors was 70.62. Data analysis also show that mean corridor width was a significant predictor of bird species richness per corridor ($R2 = 0.393$, $p < 0.001$, $n = 32$). As for mammals, this study didn't share the average species richness of the 3

types of sites but emphasized that the quality of the forest habitat a significant predictor of mammal species richness (R2 = 0.312, p = 0.001).

4. A replicated, controlled study in forests in January-April 2006 in north-eastern Brazilian Amazonia [4]. The study examined four forest strips of terra firme and four forest strips of riparian forest. All the eight forest strips are within the matrix of Eucalypus plantations but connected to huge primary forest patches in the northern end. In each forest strip, a sampling site was set near to the primary forest (<1 km), and a sampling site was set far from the primary forest (2.5–9 km). In total, 16 study sites were set in the eight forest strips. In addition, 8 study sites were set in the primary forest as control groups. All the bird data were collected with mist-nets, 432 net-hours were conducted in each sampling site. A total of 1910 birds of 117 species were caught. Riparian strips and riparian forest sites embedded within primary forest displayed similar levels of bird species richness. The species richness of terra firme strips was significantly lower than that recorded in continuous terra firme forest controls. No statistically significant difference between the species richness of 'near' and 'far' sites was detected, for both terra firme and riparian remnants. However, the species composition of 'near' and 'far' sites are different, the 'near' sites contain more species that only like the primary forest, while the 'far' sites have more species that prefer secondary forest or Eucalyptus. However, the 'far' sites have not just those bird species, which implies that forest strips can facilitate the movement of primary forest species to secondary forests and plantations.

5. A replicated, controlled study in forests in September-December 2005 in north-eastern Brazilian Amazonia [5], and this research was conducted by the same research team of [4]. This study examined four forest strips of terra firme and four forest strips of riparian forest. All the eight forest strips are within the matrix of Eucalypus plantations but connected to huge primary forest patches in the northern end. In each forest strip, a sampling site was set near to the primary forest (<1 km), and a sampling site was placed far from the primary forest (2.5km). In total, 16 study sites were set in the eight forest strips. In addition, 8 study sites were set in the primary forest as control groups. All the dung beetles were sampled using pitfall traps. 89 species in a total sample of 30565 dung beetles across the 24 forest sites were captured. Results show that isolation distance is the main contributor of species richness change, 'far" sites have smaller species richness than the "near" sites. Besides that, the abundance of dung beetle strongly relies on forest type and large mammal activity.

6. A replicated, controlled study in the dry seasons of 2013 and 2014 in the "arc of deforestation" of Brazilian Amazon [6]. This study installed camera-traps in 38 riparian forest strips and 5 riparian sites within continuous forest, the corridor width, distance to source patch, the source patch area, and the total forest proportion of each chosen riparian forest trips are different. In a total 10441 sampling days, 4459 independent records of 25 terrestrial mammal species were recorded. The average species richness

of the corridors (mean = 6.23, sd = 2.56) were only slightly lower than the continuous forest (mean = 8.76, sd = 2.22), which implies that riparian forest strips have huge potential to facilitate the flux of many forest species across the landscape. In addition, regression showed that the differences of mammal species richness and composition were significantly associated with corridor width and corridor isolation.

The referenced individual studies:

1. Vergnes, A., I. Le Viol, and P. Clergeau, Green corridors in urban landscapes affect the arthropod communities of domestic gardens. Biological conservation, 2012. 145(1): p. 171-178.

2. Gilbert, F., A. Gonzalez, and I. Evans-Freke, Corridors maintain species richness in the fragmented landscapes of a microecosystem. Proceedings of the Royal Society of London. Series B: Biological Sciences, 1998. 265(1396): p. 577-582.

3. Lees, A.C. and C. Peres, Conservation value of remnant riparian forest corridors of varying quality for Amazonian birds and mammals. Conservation biology, 2008. 22(2): p. 439-449.

4. Hawes, J., et al., The value of forest strips for understorey birds in an Amazonian plantation landscape. Biological Conservation, 2008. 141(9): p. 2262-2278.

5. Barlow, J., et al., Improving the design and management of forest strips in human-dominated tropical landscapes: a field test on Amazonian dung beetles. Journal of Applied Ecology, 2010. 47(4): p. 779-788.

6. Zimbres, B., C. Peres, and R. Machado, Terrestrial mammal responses to habitat structure and quality of remnant riparian forests in an Amazonian cattle-ranching landscape. Biological Conservation, 2017. 206: p. 283-292.

Conclusions and Recommendations

Both the theory of Island Biogeography and the summarized six empirical studies support the idea that creating corridors can bring positive impacts about species richness and abundance. However, all the six empirical studies were not human planted forest corridors. If Saving Nature (SN for short) is going to plant artificial forest corridors, SN not only needs to pay attention to the literature about corridors but also need to pay attention to the studies about artificial plantations. According to the unpublished meta-analysis done by my two teammates and me, the number of species of planted tree species can be a important influence factor.

What's more, as mentioned in the Brazil papers about birds and mammals, the width of corridors is very important too. When I was in Dr. Ryan Huang's class, I noticed he mentioned which corridor is more cost-effective than the others, but I forgot if his model also considered what width of the corridor is the most cost-effective. The length of corridor also matters. The species richness and abundance of the 'near mainland' sites seem higher than the "far mainland" sites, and this effect seem different

with different taxa.

Though fragmented habitats are everywhere, few scientists have done relevant empirical studies about corridors, which makes each relevant study very valuable. One thing I learned from Prof. Carlos Peres is if you are going to do a study about corridor, study all the taxa, study bird, mammal, and beetles together, the marginal cost is relatively small, but the marginal scientific gains can be huge.