Action: Creating Corridors to Influence Animal Behavior (exclude movement/dispersal)

Key Messages

- Two before-and-after replicated studies in South Carolina found that foraging of invertebrates was inhibited by corridors, while foraging of rodents and birds was enhanced by corridors, and Old-field mice and Cotton mice increased foraging activities on connected patches, which was also significantly positively correlated with predator presence. A replicate site comparison study in South Carolina found that Indigo Bunting nest success was reduced on connected patches because corridors encourage predator foraging.
- Two replicated, site comparison studies in South California found that Seminole bats and evening bats roost in forested corridors more than logged stands, or mature forests.

Background Information

Habitat fragmentation threatens species persistence globally (Pimm et al. 1995), while corridors were used to mitigate negative effects of fragmentation by allowing immigration to maintain population stability (Wilson & Willis, 1975). Corridors achieved the goal of preserving biodiversity and rescuing populations from extinction by increasing gene flow (Brown & Kodric-Brown, 1977). Corridors have been interpreted in various ways, while in this report, we only focus on planted corridors that have been constructed by human or natural left-over corridors that were preserved for conservation purposes. The effectiveness of corridors and the interaction between wildlife and corridors has been evaluated on multiple aspects, and the species interaction and community dynamic in fragmented landscapes with corridors are crucial to understand the conservation impacts of corridors. The effects of corridors to promote movement and to alter population genetics have been evaluated rigorously in recent years. Results of an experimental study demonstrate that corridors can maintain genetic exchange by increasing rates of transfer and interbreeding between vole demes (Aars, & Ims, 1999). Other than animal dispersal, we look at other animal behaviors in response to conservation corridors in a fragmented landscape, such as foraging and roosting. A study in a fragmented urban area northwest of Los Angeles, California found that bobcats and coyotes used natural corridors and linear fragmented areas of vegetation, as habitat and, less often, for travels (Tigas, Van Vuren, and Sauvajot, 2002). We hypothesize that both foraging and roosting behavior will be encouraged by corridors associated with the increase of wildlife abundance and occupancy.

Supporting Evidence from Individual Studies

1. A replicated, site-comparison study in 2000-2001 of seed predators on pokeweed (*Phytolacca americana*) in eight 12-ha experimental landscape at Savannah River Site, National Environmental Research Park near Aiken, South California found that corridors did not affect the number of *P. americana* germinates but affected the removal of seeds in a predator-specific manner: invertebrates removed more seeds in unconnected patches; rodents removed more seeds in connected patches; birds removed similar amount of seeds in connected and unconnected patches (Orrock *et al*, 2003). The experimental units were clear-cut mature pine forest in different shapes,

area/perimeter ratio but similar area (Winged, 19.64, 1.375 ha; rectangular, 28.95, 1.375 ha; connected, 22.62, 1.1875 ha). Seed enclosures were treated specifically for predators (NONE, no predators can access; I, access by invertebrates; IR, access by rodents and invertebrates; ALL, access by invertebrates, rodents, and birds). I and IR were found to have significant effects due to patch types ($F_{2.15} = 8.59, p$ □ 0.01; rectangular, I was 30% more than IR; connected, IR was 33% more than I; winged, IR □ I). Substrate and vegetation data were examined as possible covariates. Complementary patterns of seed removal by rodents and invertebrates suggest that corridors alter the effects of these predators taxa by changing edge-area ratio as predation pressure may change associated with the habitat overlap of invertebrates and rodents.

2. A replicated, before-and-after experiment in 2001 from May through August at the United States Department of Energy’s Savannah River National Environmental Research Park in South Carolina found that the foraging behavior of small mammals including Old-field mice (*Peromyscus poliontus)* and Cotton mice (*Peromyscus gossypinus*) is encouraged on connected patches (Robert, Haddad, & Orrock, 2005). The study sites are 40 open-habitat patches created by clear-cutting and burning pine forest between October 1999 and April 2000. In each of the 8 replicate blocks, 4 peripheral patches surround 1 central patch. One of these peripheral patches (connected patch) is connected to the central patch by a 25-m-wide clear-cut linear natural corridor, while other patches are unconnected (winged, rectangular). Givingup densities or seed removal from foraging trays were used to measure foraging activity of mice. Foraging trays were placed on three types of patches: central, connected, or unconnected rectangular. An additional intervention is the predator olfactory cues (bobcat urine) that were used to simulate predator presence. Before predator treatment, seeds remaining of central, connected, and unconnected patches were 101.2, 134.1, and 149.1. After adding cues as predator manipulation, seeds remining of three types of patch were 181.65, 54.05, and 124.6. Foraging activities decreased in central patches and the change in foraging activity differed significantly ($t = 2.29$, $P = 0.042$) between treated and untreated replicates. Foraging activity was higher in the connected patches than the unconnected both before and after adding olfactory cues (data reported as statistical table). Foraging activity in the central and connected patches was significantly positively correlated ($r = 0.792$, $P = 0.011$, $n = 9$) in the absence of predator manipulation. The study suggests that corridors have significant impact on foraging activity of small mammals, and the addition of predator presence affected the behavior in ways consistent with corridor-facilitated movement.
3. A replicate, site comparison study at the Savannah River Site, near Aiken, South Carolina, between May and August of 2002 and 2003 (Weldon, 2006) found that Indigo Bunting (*Passerina cyanea*) nest success was reduced by corridors. 40 openhabitat patches were divided into 8 replicate blocks. All patches were similar but different in shape and edge to area ratios (rectangular, 0.034; connected, 0.044; winged; 0.051). Nests were located and monitored through systematic searches of each patch in breeding seasons. Distance to two edges were measured and averaged for comparison analysis. The results show that daily survival rates for early nests were significantly lower in connected patches than in rectangular patches ($F_{1.11} = 11.17, p$ □ 0.01) but did not differ between connected and winged patches. Similarly, seasonal fecundity estimates were 45% lower in connected than in rectangular patches ($F_{1.13}$ =

7.35, p □ *0.02*), but did not differ between connected and winged patches. On average, Indigo Bunting nested closer to the edge in winged than in connected patched and closer in connected than in rectangular patches (mean distance to edge: winged, 20.1 m; connected, 23.8 m; rectangular, 26.4 m), as would be expected based on edge to area ratios. While predation was the primary cause of nest failure (88%), corridors
may influence predation by increasing connectivity for foraging predators. This study suggests that the corridors reduce nest succession rates in connected patches relative to unconnected patches but indicate that predation is increased by edge effects inherent in corridor design. However, the study does not control the interventions to determine the separate effects of corridors and edge-area ratio.

4. From late May to mid-August 2003-2006, a replicated, site comparison study in the Lower Coastal Plain in Southern California investigated the roost-site selection by 27 radio-tracked Seminole bats (*Lasiurus seminolus*) on an intensively managed landscape with forested corridors (Hein, Castleberry, & Miller, 2008) found that forested corridors had more Seminole bat roosts than logged mid-rotation tree stands or mature forest. The study area (41, 365 ha) was intensively managed by a unique forest management system, Ecosystem Based Forestry, for loblolly pine (*Pinus taeda*) production. Mid-rotation logged stands were 12-22 years old. Forested corridors (100200 m wide) consisted of mature pine (□ 23 years old) and / or mixed hardwood (□ 50 years old). Bats were caught with mist nets at nine ponds in open habitat. 27 adult evening bats (10 males, 17 females) were radio-tracked to 90 day roosts in the canopy of live pine trees. The results show that the roosts-site selection is different by sexuality in Seminole bats. Distance to nearest corridors was negatively related to roost-site selection by males and nonreproductive females (data reported as statistical model results). More Seminole bats roosted in corridor stands (reproductive female, 76%; male, 61%; nonreproductive female, 54%) . This study suggests that corridors may represent a feasible approach to maintaining suitable roosting habitat for Seminole bats in managed forest landscape.
5. Hein, Casleberry, and Miller (2009) also investigated summer roost-site selection of evening bats (Nycticeius bumeralis) in an intensively managed landscape with forested corridors in southeast South California from late May through mid-August 2003-2006, and found that forested corridors had more male but fewer female evening bat roosts than mid-rotation logged forests. The study area (41, 365 ha) was intensively managed for loblolly pine (*Pinus taeda*) production. Mid-rotation logged stands were 12-22 years old. Forested corridors (100-200 m wide) consisted of mature pine (□ 23 years old) and / or mixed hardwood (□ 50 years old). Bats were caught with mist nets at nine ponds in open habitat. 53 adult evening bats (26 males, 27 females) were radio-tracked to 75 day roosts in trees. This study found that forested corridors had more male but fewer female evening bat roosts than logged mid-rotation tree stands. More male but fewer female evening bat roosts were in forested corridors (male: 12 roosts, 39%; female: 8 roosts, 18%) than in logged mid-rotation stands (male: 6 roosts, 19%; female: 9 roosts, 21%). The greatest number of roosts were in mature forest (male: 13 roosts, 42%; female: 27 roosts, 61%). Distance to the nearest forested corridor was negatively related to roost site selection in male bats but not females (data reported as statistical model results).

Conclusions and Recommendations

From the above evidence, corridors demonstrate significant influence on foraging and roosting behavior of many species including invertebrates, small mammals, avians, and other predators. Corridors affect foraging behaviors in different ways within a given trophic level. The foraging behavior of invertebrates were mitigated with forested corridors, while predators of edge-specialists, small mammals such as rodents, and birds were found to be more active in foraging along corridors. Corridors not only support traveling between isolated patches, but also provide habitats for small mammals like bats, and avians like the Indigo Bunting to roost or nest, especially on edges. Corridor edges may encourage small mammal activity and occupancy rates, and also appear to be an important component for commuting and foraging and should be maintained across the landscape. Thus, features associated with edges can be enhanced; for instance, increasing effective overstory height to provide better habitat services. Also, wide corridors with smaller edge-area ratio are preferred for stabilizing ecosystem dynamics. Corridors may also function as ecological traps for some birds as edge effects can be magnified on predator abundance and efficiency by not only providing more suitable habitats but also connectivity between foraging habitats for predators (Bider, 1968). Thus, thorough evaluation of the impact of corridors on species interaction is essential for using corridors as a conservation tactic.

Supporting Studies

1. Orrock, J. L., Danielson, B. J., Burns, M. J., & Levey, D. J. (2003). Spatial ecology of predator-prey interactions: corridors and patch shape influence seed predation. *Ecology*, 84 (10), 2589-2599. https://doi-org.proxy.lib.duke.edu/10.1890/02-0439
2. Robert, J. B., Haddad, N. M., & Orrock, J. L. (2005). Corridors and olfactory predator cues affect small mammal behavior. *Journal of Mammalogy*, 86(4), 662-669.
3. Weldon, A. J. (2006). How corridors reduce Indigo Bunting Nest Success. *Conservation Biology*. https://doi-org.proxy.lib.duke.edu/10.1111/j.1523-1739.2006.00403.x
4. Hein, C. D., Castleberry, S. B., & Miller, K. V. (2008). Sex-specific summer roost-site selection by seminole bats in response to landscape-level forest management. *Journal of Mammalogy*, 89(4), 964-972.
5. Hein, C. D., Miller, K. V., & Castleberry, S. B. (2009). Evening bat summer roost-site selection on a managed pine landscape. *Journal of Wildlife Management*, 73(4), 511-517.

References

Aars, J., & Ims, R. A. (1999). The effect of habitat corridors on rates of transfer and interbreeding between vole demes. Ecology, 80(5), 1648+.

Bider, J. R. (1968). Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. *Ecological Monographs*, 38, 269-308.

Brown, J. H., & Kodric-Brown, A. (1997). Turnover rates in insular biogeography: effect of immigration on extinction. *Ecology*, 58, 445-449.

Pimm, S. L., Russell, G. J., Gittleman, J. L., & Brooks, T. M. (1995). The future of biodiversity. *Science*, 296, 347-350.

Tigas, L. A., Van Vuren, D. H., & Sauvajot, R. M. (2002). Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*, 108 (3), 299-306. doi.org/10.1016/S0006-3207(02)00120-9

Wilson, E. O., & Willis, E. O. (1975). Applied biogeography Pp. 522-534 in Ecology and evolution of communities (Cody, M. L. & Diamond, J. M., eds). Harvard University Press, Cambridge, Massachusetts.