LARGE SCALE PLANNING FOR CONNECTIVITY

ADINA MAYA MERENLENDER, Environmental Science, Policy, and Management Department, University of California, Berkeley, Berkeley, CA 94720-3114 USA.

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By a show of hands at the Western Section of the Wildlife Society's annual meeting in 2007, the majority of wildlife biologists have been involved in projects focused on maintaining or restoring habitat connectivity in order to enhance species persistence in fragmented landscapes. Corridors, routes that allow movement of organisms between habitat fragments, are increasingly being adopted as a tool to maintain and restore biodiversity. However, we know relatively little about whether presumptive corridors actually serve as conduits for movement of organisms. Yet, we do know that relying entirely on protected areas for biodiversity conservation is not going to be sufficient, and that suitable habitat needs to be maintained for many species outside of reserves, and that linkages may be required among habitat patches to prevent local extinctions.

Scientific principles and theories that scientists and conservationists draw on to design and implement landscape linkages include island biogeography and metapopulation theory. These theories point to the fact that patch size and relative isolation can influence the total number of species found in any given area and the need for migration among subpopulations of animals and plants. Many people working on corridor design struggle with defining the properties of the corridor itself. Whether man-made or natural, structural definitions for corridors are popular. Generally corridors are linear in shape and provide a connection between habitat patches of the same community type and provide a more natural pathway distinct from the adjacent matrix. Rules of thumb do exist, such as longer corridors usually need to be wider to provide sufficient habitat for species to pass through the full length of the corridor. Corridors may be continuous or not as is the case for stepping-stone corridors that can work for some flying species or those willing to pass through the modified landscape in between (Fig. 1). However, for small mammals, gaps of more than 4 m can present a barrier to movement. What is really important is whether the solution is fostering connectivity better than business as usual, which depends on the species of interest and landscape context. For example, insights from landscape ecology reveal that what surrounds a potential corridor must be considered, as some modified landscapes are more permeable than others. The landscapes surrounding core habitat and corridors, also referred to as the matrix, may directly influence connectivity, and it may affect the utility of corridors that pass through it. Unfortunately, there is

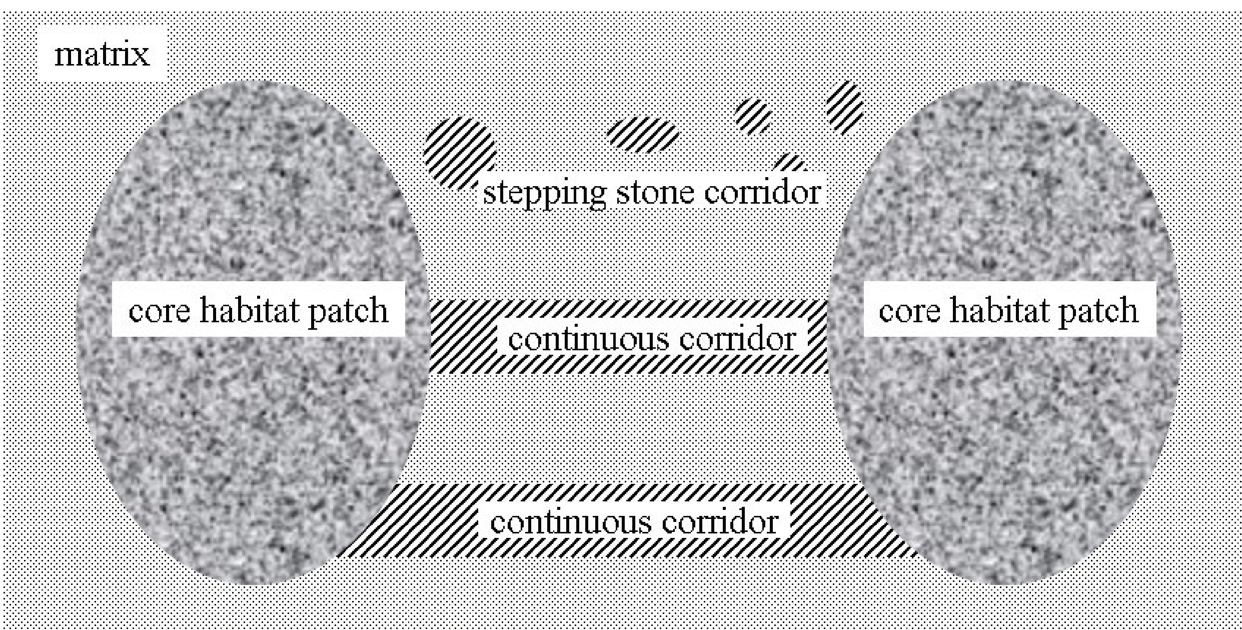

Figure 1. Corridor schematic (by Jodi Hilty).

a limited amount of information on how the mosaic of habitats across the landscape can affect biodiversity patterns and ecosystem processes.

In addition to the fact that the benefits of corridors for connectivity may not be achieved, there can be costs or undesirable impacts associated with increased connectivity and corridor establishment. Those adopting the corridor concept should be aware of potential pitfalls that can occur, especially when restoring connectivity or conserving a limited number of restricted corridors. One primary problem is associated with edge effects, which are well documented for forested systems and include changes in local climate that can negatively affect forest interior species while positively affecting other species (Forman 1995, Laurance 1997). Generalist predators and exotic species are often edge species and sometimes out-compete specialists and native species. They can also contribute to increased predation, competition, and parasitism on native interior species (Beier 1993, Murcia 1995, Stefan 1999). Narrow corridors may be considered entirely made up of edge habitat and may not serve species reliant on interior forest. Also changes in the community composition within the connected patches can result from differential use of corridors among species; and if species are strongly dependent on one another, losses of one can lead to a cascade of local extinction events.

Corridors may facilitate the invasion of exotic species, deleterious native species, or pathogens into habitat patches where they previously did not exist. The corridor itself may result in secondary habitat that draws individuals in, but where reproductive output is generally insufficient to maintain the population, and therefore results in a population sink for the species. Corridors may be inadequate for dispersal of social groups resulting in changes to social organization that can impact species persistence. Genetic consequences of enhancing connectivity can include outbreeding depression, which results from individuals breeding that are quite distantly related or adapted to different habitats. The resulting offspring may turn out to be not well adapted to either of the original habitat types, or they may exhibit some other genetic problems as is common with hybridization. Being aware of these and other potential pitfalls that can occur may help us to avoid them.

Problems can also result when there are conflicting objectives set forth; therefore, corridor projects must be clear about objectives and address potential economic impacts such as cost of acquisition and construction, maintenance, and monitoring. Of course their can also be economic benefits such as educational opportunities, enhanced scenic beauty, and ecosystem services. In addition to clear objectives, planning for a corridor project must involve a dedicated team, working with partners and stakeholders through collaborative conservation, and communication with the public. Being clear about the many assumptions that are being made and the hypotheses that need to be tested is also important because there is a great deal of uncertainty when it comes to designing and implementing corridor projects.

Corridors range in scale from small road underpasses to large landscape connections that cross multiple countries. Fine scale data is required to address local projects while coarser geographic information may be the best place to start for large-scale projects. Geographic information systems are an essential tool to identify corridors, coordinate project implementation, and monitor impacts for adaptive management. Often spatially explicit maps and models of habitat suitability for focal species can be used to identify the path of least resistance that individuals may be able to preferentially move through. This process has been used to identify wildlife corridors in southern California, as discussed by Paul Beir during this plenary session. While existing vegetation cover and species distribution maps are often the most desirable type of information for corridor planning, I can not overly stress the importance of mapping the built environment as well. Often digital information is available for developed areas from city and regional governments. Such digital information can include existing roads, property ownership boundaries, human census data, jurisdictional boundaries, and urban service areas. Of particular importance is identifying potential barriers to animal and plant movement such as roads or intensively developed areas. Confirming that the maps are accurate on the ground is desirable but often not practical or possible, especially for historical data. If both present and historical information on the development footprint is available for large planning areas, then spatially explicit statistical models can be developed to forecast future land-use change to estimate future threats to unprotected habitat.

The relative threat and costs of potential sites is important, in addition to focusing on which corridors will provide the most biological benefit. This will help avoid investing in sites that, by default, will continue to provide connectivity without any further action. Therefore, it is important to estimate the relative probability that a site will be lost and the relative cost of conserving it compared to other sites in order to prioritize corridor conservation. Threat estimates require information on likely future development patterns in the region; and costs that may need to be considered are property values, the price of restoration treatments, and future stewardship expenses. I want to recommend that planning for corridor conservation should include determining the probability of loosing each potential linkage over the cost of protection to prioritize conservation efforts.

Also, feedback from local experts and the public is essential to validate any conservation-science planning effort.

The last but not least step in planning for connectivity is to include assessment and validation of any corridor program. This should include evaluation of site characteristics and quality as well as surveys of animals and plants on the ground prior to implementation. Also, continued monitoring of focal species and habitat integrity along the corridor and surrounding habitats is essential for adaptive management – an important step for long-term protection of habitat connectivity (Fig. 2).

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Figure 2. A grey fox (*Urocyon cinereoargenteus*) with prey taken by a remotely triggered camera along a riparian corridor in Sonoma County, California. (Photograph by Jodi Hilty).