EDITORIAL

Links and Winks—The Design of Ecological Corridors

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"Once upon a time. . . ."

This is our invocation of memory, but also of fantasy. The efforts being made to design ecological corridors are grounded in the memory of a more connected physical landscape, with a more reliable ecological function. Our past human actions have given us structures that dominate the natural landscape, severing demographic and genetic connections. Human and ecological health needs, now urgent, will require stitching together the pieces. Is our stitching in time? Can a rendered ecological fabric be repaired?

Success will require links among professional disciplines, not just between landscape parcels. In this Special Issue, we address a variety of perspectives necessary for progress: scientific fact-finding; architectural design explorations; public policy initiatives; and scale of action, from microsite to continental. We also offer journalistic scope from detailed, analytical black-and-white figures, to the knockout, 16 pages of living color of landscape architecture innovations. Have we gotten your attention? There's a design world out there for the ecological community to meet. Invite them over (a wine bar will do)!

The creation of ecological corridors is deliciously complex. The scale of concern varies in space. Movements of small animals can even be stopped by a concrete curb, but this barrier can be remedied by an acute-angled street border (Figure 1), a design feature that is, alas, rarely used. The scale expands through road crossings, highlighted by the elegant designs in this Special Issue, then through neighborhood greenways and the rails to trails movement (e.g., www.railstotrails.org) across many kilometers. Tens and hundreds of kilometers can be joined by regional networks and continental efforts such as the Yellowstone to Yukon conservation initiative (y2y.net), as discussed in this issue's Perspectives and Restoration Notes sections.

Sometimes the large-scale networks are not spatially continuous. For example, in the well-known case of securing whooping crane (*Grus americana*) migration pathways, the need was not real estate between Texas and northern Canada reserves, but rather education, as much of the area was a flight path, not an earthbound trail (Figure 2). Educating the public that those big white birds were not to be hunted was a major effort to maintain this grand species (ICF 2012). Similarly, in Costa Rica, some moths required land both in the mountains and in the dry forest lowlands (Allen 2001) to complete their life histories; high elevation land was needed to secure the migration destination. Large-scale corridors, whether earthbound or aerial, will need a level of public understanding that is sophisticated.

In a time of changing climate, the ability of many species to move large distances is urgent. We know that species have moved across hundreds of kilometers during geologic time scales as the glaciers retreated (Davis 1983).

Figure 1. Acute curb cuts allow the movement of small animals such as turtles, lizards, and small mammals across concrete barriers that may be only several centimeters high but can be lethal. This structure is at the Sebonack Golf Club, Southampton, New York.

Ecological Restoration Vol. 30, No. 4, 2012
ISSN 1522-4740 E-ISSN 1543-4079

Figure 2. Whooping crane (*Grus americana*) habitat in North America is divided between coastal Texas and northern Canada habitats. Many hundreds of kilometers must be crossed in the air to migrate from one area to the other. This is a necessary part of the species migration corridor but is not represented on the ground. This aerial corridor was the source of much mortality before an intensive education campaign aimed at waterfowl hunters. (Reprinted with permission from the International Crane Foundation).

Climate change is the anti-glacier, a movement of heat, not ice, across the hemisphere. The role of corridors is more urgent now than in the times before humans carved up the landscape.

Variation in scale of corridors is a product of species niche requirements and the complex reasons why plants and animals move at all. (Plant movement can be by pollen, seed, or vegetative structure, such as the shed twigs of riverine willows [*Salix* species]. Plant movements may be slow and not apparent, but they are real.) Lewontin (in Baker and Stebbins, 1965) wrote that *all* species have colonizing stages; it's just that they vary with life history requirements. Some species are continually in motion, while others have episodic movement. Our challenge as restoration ecologists and landscape designers is to satisfy a wide menu of needs, from seasonal migrations to feeding sites and breeding arenas, to escape routes from stresses (fire, predation, food limitation, climate change, human activities). Movement is needed for both ecological and evolutionary progress (Silvertown and Antonovics, 2001). Individuals' movements yield mixing or separation of populations. This has immediate genetic consequences from breeding systems to adaptive radiations. Corridors must indeed provide different strokes for different folks. Additionally, one corridor size will never fit all. The solutions discussed in this issue's highway crossing designs do attempt multi-species solutions. Will they succeed? What scientific facts can behavioral ecologists offer to advance the designs?

There are problems in creating corridors at every scale, and we can't coyly wink and ignore them. Professional attitudes between scientists and designers are sometimes in conflict. The precision which is the hallmark of physical sciences, engineering, and regulatory wording does not sit well with the variation and subtlety of changing niche parameters with which ecologists wrestle. The tight tolerances that mark success for an engineer must face the frequent deviations from the mean that ecologists accept as part of our modern science. Feeding and mating territories change in size as quality of the habitat changes, and consequently movement patterns change (Bullock et al. 2002). There is not stasis in size when habitat quality varies in time. Many landscape architects are eager to associate with restoration ecologists, but the dancing is in the dark until these different perspectives can be illuminated.

Second, mapped and designed corridors are only part of the solution for population movements. Adjacent areas are often used by organisms during movement episodes (whether daily or seasonally), and these must be part of the landscape ecology design (Bennett 2003). Design concern must be wider than the "real estate boundary" of the new corridor. For example, lights in adjacent areas have strong ecological effects on organisms within the corridor (Rich and Longcore 2006). Also, invasive species regularly move

in from adjacent areas and degrade the community structure in new corridors. Corridors near human settlements are affected by feral dogs, cats, and mountain bikes. Design solutions, such as fences around corridors, may be counterproductive. Fences can make prisons for organisms within the corridor when stresses like drought or fire occur. In these situations good fences do not make good neighbors.

Third, in the initial planning as to where to place a corridor, land purchase or negotiation for a conservation easement is often necessary. Determining which parcel should be obtained is not always an intuitive decision. Given only occasional movements that may be required for population persistence, fieldwork in one year might not reveal the needs of other years. Sometimes "low-quality" land is the necessary link between higher quality habitats, which looks quite different and must be secured. Budgets for governments and nonprofit environmental groups are always tight, but the intelligent action may be buy, buy, or it's bye-bye.

This Special Issue confronts this jigsaw puzzle of issues from a suite of perspectives, both desperate and disparate. In the creation of a functional landscape ecology in today's human dominated land, certain links are missing, and other links are weak. The entire structure of our ecological world may never be made complete, and we can't wink this reality away. As children we learn that, *"All the king's horses and all the king's men, couldn't put Humpty together again."* But even if our world is missing pieces, incomplete, it can be made better functioning. Ecologists and designers, like those royal horses and men, must work together as a conceptual corridor to move from the broken past to a mended future.

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