EDITORIAL

Opportunities Found In a Worm Hole

European earthworms may lie at the root of persistent problems with some invasive plants in the Midwest. In conversations with colleagues here at the University of Wisconsin–Madison Arboretum, I've been learning about how recent research on invasive synergies or "invasional meltdown" is demanding some new approaches to restoration and land management. A growing number of studies support the idea that the robust persistence of undesired European buckthorn in many areas may be due in part to the presence of non-native earthworms (Heneghan et al. 2004, 2006; Skinner 2005). European earthworms, arriving to southern Wisconsin with settlers, are altering soil chemistry and nutrient cycling in ways that promote conditions favoring invading plants—such as European buckthorn—and inhibiting the reproduction of native plants.

Buckthorn leaves are very high in nitrogen and an excellent food source for earthworms. Earthworms consume the leaf litter layer and mix the top portion of the soil, modifying nutrient cycling and leaving bare ground, which is ideal for buckthorn seedlings and seed germination but which inhibits many native plant seeds from germinating (Knight et al. 2007). This synergy between earthworms and buckthorn is suspected to have residual effects, so that even after buckthorn is removed the modified soil processes will inhibit restoration efforts aimed at reintroducing a diversity of native species.

The Arboretum is the site of some of this country's first and most famous efforts at ecological restoration. Curtis and Greene prairies were established over 60 years ago through painstaking and careful work seeding and importing prairie plants to agricultural land, sometimes a single plant at a time, in order to recreate the complexity and beauty of remnant tall grass prairies in the area. Contemporary land management and restoration efforts at the Arboretum strive to maintain these restoration plantings, many of which are in constant danger of encroachment from buckthorn and other undesired plant species. As I've learned through volunteer work here, buckthorn is a threat in prairies and in forests, edging out plant species that are either native or were brought in as part of Arboretum plantings.

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The idea of invasional meltdowns with legacy effects, and the notion of an underground, and therefore mostly invisible, invasive species, not to mention one that enjoys a general reputation as a friend to the soil, offers a whole new set of challenges—and opportunities—for restoration efforts at the Arboretum. Much of the land management at the Arboretum is accomplished with the assistance of volunteers, who are often cutting, herbiciding, and burning invasive plants. How reasonable is it to ask volunteers to continue to fight buckthorn, knowing that under our feet ongoing soil processes may continue to prevent native plants from establishing? How feasible is eradicating "invasive" earthworms?

As is true with many invasive species, human activity lies at the very roots of this synergistic invasion. Theories of "invasive networks," which include human activity, focus on the critical human role in creating, defining and perpetuating invasions (Robbins 2004). Glaciation eradicated native earthworms from this region, for example, and the ubiquitous presence of European earthworms across southern Wisconsin is the result of agricultural, horticultural and other human activities since European settlement. The buckthorn tree was first brought to the United States from Europe in the late 1800s, and widely disseminated for horticulture, forestry and wildlife plantings, and to create shelterbelts in agricultural fields.

A look at land use in the UW Arboretum reveals how people opened up the land for buckthorn and other disturbance-adapted species by removing vegetation, plowing, grazing, importing plants and soil, and building roads for subdivisions. The Arboretum is completely surrounded by urban development, but within its boundaries, many acres have passively revegetated. These acres are not only cut off from other natural areas, however, but also experience ongoing low-level disturbance from many paths throughout the forest.

The upside of understanding invasive synergies is that we are strongly encouraged to explore more nuanced and realistic restoration and management goals. Invasive networks insist that we rethink our relationships with the nonhuman world. Where we once thought ourselves to have a relationship of control, we now need to consider levels of risk, uncertainty, and even humility and trust. Creative and targeted management strategies informed by these new relationships might include what Foster (2003) describes as "measured cohabitation," where we don't just combat, but live and work

with plants and animals in multiple ways. Outside of a restoration context, I am familiar with many examples of such measured cohabitation, such as organic farmers who "read" weed species in their fields in order to better understand the health of their soil (Gershuny and Smillie 1999).

Certainly cohabitation with buckthorn is not an option in Curtis or Greene Prairie, where our faithfulness to the classical model of restoration is of great cultural, scientific and economic value. Even there, however, we have an opportunity to rethink our approach to invasive species, which might be especially valuable to the volunteers whose labor is so critical to maintaining restorations. We can emphasize the role humans play not only battling invasives, but nurturing prairies, which, if left to "go back to nature" would certainly be overwhelmed. This is a point Tom Simpson expands on very well in his article in this issue of *Ecological Restoration*.

In other areas of the Arboretum, however, we lack the resources to maintain this level of nurturing. As a new approach we might shift our restoration focus to ecosystem function. In the Arboretum's Southwest Grady Oak Savanna, for example, buckthorn has persisted despite years of volunteer efforts to eradicate it. A new restoration goal might be to investigate the minimum level of buckthorn removal required to still successfully burn the area, a basic ecosystem function needed to maintain the open savanna.

The Lost City Forest in the UW Arboretum is the site of a failed residential development in the early 1900s. Given the high level of past and current disturbances in and around these mixed woodlands and their isolation from native plant communities, here we might investigate ways the existing plants affect nutrient cycling and soil fertility. This reforestation can be viewed as one step in an ever-changing landscape, and that current synergies may create conditions we can take advantage of to encourage the regeneration of native species at a later time (Lugo 2004). We might experiment with gradually shifting plant communities in order to work with the more fertile soil conditions left by buckthorn even after the plant is removed, discouraging earthworms with various types of plantings, but also working with species that will respond better to more fertile soil, and perhaps prepare it for native plants we want to see thrive.

Between 1933 and 1937, Civilian Conservation Corps crews planted the Leopold Pines, an area of red and white pines along with small numbers of red maple, white birch and some northern shrubs and ground layer plants, as part of an effort to establish an example of the northern Wisconsin pine forests. These plantings have had very limited success, and the shade of the pine trees encourages brushy growth such as buckthorn within and around the pine plantation. Here we may be best off humbly acknowledging our inability to recreate northern Wisconsin plant communities. More successful may be a completely new type of planting that would mean giving up the challenging goal of northern pinewoods wildflowers, but would discourage the undesired brushy growth.

The exercise of tracing an invasive network at the Arboretum involving earthworms, buckthorn, and people provides opportunities for several important shifts in perspective on restoration and associated management goals. The exercise illuminates the human role in creating conditions for disturbance and invasion; as a kind of corollary, they also emphasize the strong human role in nurturing classical, historically-faithful ecological restorations. We can think about our management strategies as moving beyond simply trying to control buckthorn, to consider a range of cohabitation possibilities. Just how much buckthorn must be removed for an area to successfully achieve the ecological function of burning? In addition, we can anticipate that the buckthorn-worm synergy will influence other aspects of the ecological system. We can assess how living with buckthorn and worms is changing soil processes, for example, and experiment with new restoration goals and plant species that might thrive in the changed soil conditions. Invasive synergies and networks need not mean defeat. To the contrary, they demand that we develop new, more complicated understandings of our relationships with the nonhuman world, and realize the potential for new management goals.

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Editor

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