VEGETATION SURVEY OF PRAIRIE RECONSTRUCTIONS AT LITZSINGER ROAD ECOLOGY CENTER

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Abstract: The Litzsinger Road Ecology Center (LREC) is a 13.8-ha (34-ac) site in suburban St. Louis, Missouri. The site includes 4.9 ha (12 ac) of mesic to wet-mesic prairie reconstructions (restorations), most of which were seeded in 1989. Management activities in the prairie included prescribed burns, invasive species control, interseeding, transplanting, and mowing. Our goal was to establish a bio-diverse prairie that contains conservative plant species. In 2001, we established a vegetation-monitoring grid to evaluate management practices and restoration progress. In our surveys, we found a total of 216 plant species, 179 of which were native and 37 of which were non-native. We found an overall mean coefficient of conservatism of 4.0 and a floristic quality index of 53.5. The numbers of non-native species, mean coefficient of conservatism and the floristic quality index (FQI) were similar to those of remnant prairies of similar size; however, the native species richness at the LREC was lower than in some remnants. Within plots at the LREC, the mean native plant species richness (alpha richness), mean coefficient of conservatism and FQI were significantly lower than the mean observed values of plots at remnants. While the restoration methods used at the LREC have promoted an overall level of floristic quality and presence of species of conservation value similar to that of remnants, native species are still missing in the system and individual plot data indicate their distribution is not yet similar to what would be seen at a remnant.

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The Litzsinger Road Ecology Center (LREC) is an environmental education center located in suburban St. Louis County, Missouri, USA (38 37' 32.80" N, 90 22' 44.19"W) that is managed by the Missouri Botanical Garden. The LREC is dedicated to promoting science teaching and learning, environmental literacy, and stewardship.

At the time of this writing, the main goal of the prairie reconstructions at the LREC is to be a center for place-based education (Sobel 2004), educating elementary and secondary school students about prairie habitats that historically occurred in Missouri and in particular, about the rich prairie that once dominated the vegetation of

St. Louis. We teach students about the organisms that constituted these communities and involve them in the restoration process to connect them with their local environment and to help the LREC to reconstruct high biodiversity ecosystems. Students learn about the ecological, historical, and aesthetic importance of the prairie ecosystem. Restoration of prairie habitats in riparian corridors also helps to preserve the soil and increases water infiltration, slowing storm water runoff in an urban landscape (Weaver 1968, Broughton and Apfelbaum 1999). Another important goal of prairie restoration at the LREC is conserving the genetic and species diversity of the now endangered tallgrass prairie ecosystem.

Tallgrass prairie at one time covered a third of Missouri (Schroeder 1981), and as of 1999 (Ladd 1999), only 0.6% of this original prairie remained, due to conversion to agriculture and urban development. Throughout its range, the tallgrass prairie is one of the most endangered ecosystems in North America (Samson and Knopf 1996). Due to its extreme rarity, restoring the tallgrass prairie and monitoring the progress of these restorations is important. Repeatedly collecting data from prairie restorations and comparing them to remnant prairies allows managers to adapt their techniques in order to achieve the goal of restoring tallgrass prairie ecosystems (Elzinga et al. 1998).

Because our restoration efforts have primarily focused on plant communities once present at the LREC rather than animal communities, we chose to monitor the plant species present in the prairie reconstructions using permanent vegetation monitoring plots. To evaluate our restoration, we compared distribution and composition of the plant species growing at the LREC to those at native prairie remnants in Missouri.

STUDY AREA

The grounds at the LREC comprise 13.8 ha (34 ac), 4.9 ha (12 ac) in prairie reconstructions, 5.7 ha (14 ac) in bottomland woodland that surrounds 0.8 km (0.5 mi) of Deer Creek, and 3.2 ha (8 ac) in buildings, cool season grass fire breaks, and native landscaping. The LREC began the prairie reconstruction project in 1988. Staff sowed Sudex, a cover crop (Davit 2000), on 4.0 ha (10 ac) of old-field formerly in corn and wheat (H. Potter, Litzsinger Road Ecology Center, personal communication). The field is in the floodplain of Deer Creek and has silt loam soils developed from an alluvium substrate (Butler 1998). The Sudex helped to shade out native annuals, non-natives, and other opportunistic plant species growing in the field. It is also purported to have an allelopathic function (Weston et al. 1989). The field was mowed, burned and harrowed. The following year, staff sowed 41 species of locally collected prairie forb seeds and 8 species of prairie grass seeds purchased from seed nurseries in northwestern Missouri and eastern Kansas (Davit 2000). Some of the seed on the 4.0 ha (10 ac) was hand broadcast and raked in, and some was sown with a seed drill. This area was divided into 2 sections of 1.6 ha (4.0 ac) and 2.4 ha (6 ac). A 15.2–m x 30.4-m (50-ft x 100-ft) area on the southwest corner was hand-planted with 18 forb species and 4 grass species. Plants and seeds continue to be added to the prairie by student restoration groups. In 1998, the LREC staff began a second restoration project in a former horse pasture. A 0.6-ha (1.5-ac) section was sown with 34 species of locally collected seed in 1998, an additional 0.2 ha (0.5 ac) adjacent to it was sown with 81 species of locally-collected seed in 2004. Plants and seeds continue to be added to these reconstructions.

Wet-mesic bottomland prairie was the appropriate target community for this area based on historical accounts. According to the surveys of the St. Louis region conducted by Soulard during 1796-1806, the Deer Creek Valley bottoms and all the land along Litzsinger Road (where the LREC is now located) was prairie (Schroeder 1981). Wet mesic bottomland prairie is a particularly rare type of prairie. Most of it was converted to agriculture due to its rich silt loam soils derived from alluvium and usually flat topography (Nelson 2005). Invasion by non-native species and the changed flooding regime due to stream channelization, increase of impervious surfaces such as asphalt and concrete, and conversion to croplands are major current threats to remaining wet-mesic bottomland prairies (Nelson 2005). The rarity of this ecosystem and fragility of remaining parcels of wet- mesic bottomland prairie are further reasons that the success of this reconstruction project is important.

METHODS

In 2001, we established 138 permanent, 0.25-m^2 (2.69-ft^2) monitoring plots on a 15-m x 15-m (49-ft x 49-ft) grid to monitor plant species growing in the prairie. We decided on a permanent grid of this size because it would capture change in vegetation over time and contained a sufficient number of plots per area to find the species within the prairie as measured by a species accumulation curve (Hiser et al. 2002). We began monitoring 2 of the 3 sections of prairie in 2001, alternating which section would be monitored each year. The first section was monitored in June, July and August. In 2002, we determined that monitoring in June and August was sufficient to observe all the plant species present, and we switched to monitoring twice per year. In 2005, we added a third section of prairie to the monitoring rotation. To monitor the plots, we identified all of the species of vascular plants that were rooted within each plot and estimated the percentage of cover for each species using cover classes 1 through 5 developed in part by Ladd and Heumann (1995), but see Braun-Blanquet (1965).

Additionally, we looked for other species not located within plots as we walked between plots and recorded these as part of the species list for the prairie. We identified specimens in the field when possible. When unable to identify specimens in the field, we collected specimens from outside the plots and later identified them using Steyermark's Flora of Missouri Volume I (Yatskievych 1999) for monocotyledons and Flora of Missouri (Steyermark 1963) for dicotyledons. When identification was still not possible, we asked the aid of botanists James Trager, George Yatskievych, and members of the Missouri Native Plant Society. We followed the Catalogue of the Flora of Missouri (Yatskievych and Turner 1990) for nomenclature.

To each of the plants we identified, we assigned a coefficient of conservatism (C of C) defined by Ladd (1993) based on the fidelity of these plants to their habitat (Swink and Wilhelm 1994). The C of C value ranges from 0 to 10, with plants receiving 0 being native weeds that can occupy many disturbed habitats and 10 being plants that have high fidelity to a specific intact ecosystem. Non-native plants do not receive a C of C value. We were aiming to create a wet-mesic tallgrass prairie, such that the presence of plants highly loyal to this habitat would that was a good indicator that the structure and composition of reconstruction was progressing. We also calculated the floristic quality index (FQI) for each plot and the site by taking the square root of the number of native species and multiplying by their mean C of C (Swink and Wilhelm 1994). We assumed that the higher the FQI, the closer the restored community reflected the structure and function of remnant prairies. By analyzing habitat fidelity of plants present, the C of C and FQI can be more informative about differences between habitat quality than traditional species diversity measures (Taft et al. 2006).

We compared our results at the LREC with those from 3 remnant prairies studied by the Missouri Prairie Foundation (MPF) of similar size (15-32 ha or 37-80 acres) and soil type (silt loam) to the LREC: Drovers Prairie, Friendly Prairie, and La Petite Gemme (Ladd and Churchwell 1999). These prairies are in a different portion of the state than the LREC (western and southwestern Missouri) and are growing on a different substrate that that of the LREC (chert and limestone vs. alluvium at the LREC); however, complete data do not exist for prairies that are closer or of more similar substrate, so this was our best reference data. Surveys at these prairies were conducted in a similar way to those at the LREC, using 0.25-m^2 plots in which all plant species were identified, and C of C (Ladd 1993) and cover classes (Ladd and Heumann 1995) were assigned to each species. We also compared our number of plant species to those found at Tucker Prairie, a prairie on silt loam soil in central Missouri near Columbia, which may be more similar in composition to what might be expected at the LREC, because it is closer than the MPF remnants. However, Tucker is much larger than the LREC at 59 ha (146 ac) (Davit 1999) and is derived from loess-limestone substrate (Nelson 2005). No plot level data were available for Tucker.

All species found at any time were included in the overall prairie plant list. Because the overall data for the LREC plant surveys were based on all of the information from all years from all sections of the prairie, we had only 1 sample value from the LREC for overall native and non-native plant species richness, FQI and C of C. Therefore, we could not conduct a t-test to compare the results at the LREC to those at the MPF prairies. Instead we compared our data with those at MPF prairies by comparing 2 standard deviations around the mean values for the MPF data.

All prairie sections were monitored multiple times. To analyze the data from the multiple monitoring times, we included all species recorded in a prairie plot throughout 1 season as part of the species richness of that plot. For the sections monitored > 1 year, we took the mean species richness per plot for the 2 years for analysis. We conducted Student's 2-sample t-tests (Moore 2000) to compare per plot mean native and non-native plant species richness, FQI, and C of C at the LREC prairies with MPF prairies.

RESULTS

We found 216 species of plants at LREC – 37 species were non-native, 179 species were native, including 66 plant species not located within plots found on walk-through surveys. The most commonly occurring species included: tall goldenrod (*Solidago altissima*) in 86% of plots, sweet coneflower (*Rudbeckia subtomentosa*) in 67% of plots, smooth beard-tongue (*Penstemon digitalis*) in 50% of plots, and big bluestem (*Andropogon gerardii*) in 49% of plots. Of 36 dominant and characteristic plants of wet-mesic bottomland prairies (Nelson 2005), 9 were not present at the LREC. These plants included: Allegheny monkey flower (*Mimulus ringens*), bluejoint (*Calamagrostis canadensis*), common lousewort (*Pedicularis canadensis*), cowbane (*Oxypolis rigidior*), Indian plantain (*Cacalia plantaginea*), loosestrife (*Lysimachia lanceolata*), loosestrife (*L. quadrifolia*), Michigan lily (*Lilium michiganense*), and tall white aster (*Aster lanceolatus*). As expected in a grassland ecosystem, the most common plant families at the LREC included: Asteraceae with 25% of species, Poaceae with 14% of species, Fabaceae and Cyperaceae each with 6% of species, and Rosaceae with 5% of species.

Of the non-native plant species that we found, only 4 were considered to be disrupting native plant communities in Missouri by the Missouri Exotic Pest Plant Council (Gaskin et al. 2002). These were: crown vetch (*Securigera varia*), tall fescue (*Festuca arundinacea*), white sweet clover (*Melilotus albus*), and wintercreeper (*Euonymus fortunei*). None of these occurs at great frequency within the LREC prairie (none was in more than 5% of plots).

We found a mean C of C of 4.0 and a mean FQI of 54 at the prairie at LREC. The most prairie-restricted species (Ladd 1993, Nelson 2005) at LREC include: blazing star (*Liatris scariosa*), bunchflower (*Melanthium virginicum*), closed gentian (*Gentiana andrewsii*), gerardia (*Agalinis viridis*), purple prairie clover (*Dalea purpurea*), rattlesnake master (*Eryngium yuccifolium*), royal catchfly (*Silene regia*), and smooth milkweed (*Asclepias sullivantii*). Joe-pye weed (*Eupatorium fistulosum*), queen of the prairie (*Filipendula rubra*), and rose turtlehead (*Chelone obliqua*) are species restricted to wetland habitats (Ladd 1993, Nelson 2005) at LREC. Of these species, only 2 species were found within the plots, few are in populations larger than 100 stems, and the location of the individual or clump of several of these rare plants was already known prior to the survey due to planting records.

At the remnant prairies, MPF surveyors found a mean of 240 native species and 41 non-native species. Although the number of native species was larger in MPF remnants than at the LREC, it was not significantly larger. The number of non-native species at the LREC was similar to those of MPF remnants. Tucker Prairie contains 224 species, which is more species than are at the LREC. Overall, the LREC does not significantly differ in numbers of native or non-native plant species than a comparably sized prairie remnant. The overall mean C of C at the LREC was not significantly different from MPF remnants (3.87). The FQI was also not significantly different at MPF remnants (60.3) than at LREC.

We found an average of 8.01 native plant species per plot (alpha species richness) at the LREC in comparison to a mean of 16.00 native plant species per plot in MPF remnants. The

LREC had a statistically significantly lower species richness than MPF remnants ($p < 0.0001$). Statistically, the LREC does not have more non-native species per plot (1.27) than MPF-surveyed remnants (0.13, $p > 0.10$). The LREC also had a significantly lower mean C of C (2.79) than that present in MPF remnants (4.07, $p < 0.001$). We also found a significantly lower FQI at the LREC (7.18) than at MPF remnants (16.37, $p < 0.0001$).

DISCUSSION

Overall, the management practices at the LREC have been successful in recreating the number and ecological conservatism of plant species that one would expect in a wet-mesic tallgrass prairie. However, the LREC prairies are missing some of the key species that are characteristic or dominant plants of wet mesic bottomland prairies (Nelson 2005). We plan to add these species and other native plant species by seed and plantings to increase overall plant species richness and to conserve more plant species characteristic of wet-mesic bottomland prairies. These additions will result in the LREC becoming more similar to the prairie remnants in this area of Missouri.

Of the non-native plant species that we found, 4 were considered to be invasive species. We primarily manage these invasive species within the prairie by burning to kill fescue and wintercreeper, hand pulling white sweet clover in the summer, and spot spraying crown vetch with Roundup or Garlon 3a in the spring.

On a fine-scale basis, there is more work to be done. The local scale plant species richness (alpha richness) needs to be increased. We have many plant species at the prairie overall, but they are not spread as evenly as they are in remnant prairies. A few species tend to dominate most of the area. This difference between LREC prairies and MPF remnants may be due to differences in soil type or nutrient availability; however, restorations with low local-scale plant species richness are relatively common (Martin et al. 2005, Polley et al. 2005), and the high local scale plant diversity of the MPF remnants is typical of other prairie remnants in the Midwest (Bowles and Jones 2004). High residual levels of nitrogen in pastures and farm fields used for restorations may be causing alpha diversity to be lower in restorations relative to remnants, since species richness and nitrogen levels are generally negatively related (Wedin and Tilman 1996, Stevens et al. 2004, Clark et al. 2007, Price and Morgan 2007). Local disturbances caused by grazing in remnant prairies (Collins et al. 2004) may also be a factor in increasing alpha diversity in remnants relative to restorations. Another likely cause of low alpha diversity in restorations may be low seed availability and prohibitive costs of certain species (Diboll 1997).

To address the differences we found between LREC prairies and MPF prairies, we will manage dominant native species, particularly tall goldenrod, which is considered an aggressive native species in the Midwest by managers (Czarapata 2005), by spot-spraying or painting cut stems with Roundup or mowing to help provide niche space for other plant species (Martin et al. 2005). We also plan to add hemi-parasitic species such as common lousewort (*Pedicularis canadensis*), Indian paintbrush (*Castilleja coccinea*), slender gerardia *(Agalinis tenuifoilia*), and swamp lousewort (*Pedicularis lanceolata*) to the prairie to reduce the height and dominance of aggressive natives such as tall goldenrod and warm season grasses (Handel 2000). We will spread seed, particularly from high-quality prairie-dependent species gathered from within the site, more evenly to increase numbers of native species at a fine scale within plots and increase the C of C value within plots.

MANAGEMENT IMPLICATIONS

Managers frequently overlook fine scale diversity at the plot level. Because animal diversity is often positively related to plant diversity (Hutchinson 1959, Siemann et al. 1998, Zhao et al. 2006), managers assume that where there is a large number of plant species, there will be a large number of animal species. However, fine scale (alpha) diversity may have a significant effect on the biodiversity of the whole system since organisms operate at different scales (Huston 1999, Gathmann and Tscharntke 2002, St. Pierre et al. 2005). For instance, the oligolectic bee, *Andrena (Trachandrena) quintilis,* which is dependent on lead plant (*Amorpha canescens*) (Slagle 2004), might not be able to locate the few plants documented by plant surveyors at the LREC, but if lead plant were spread more evenly, the bees might be able to locate it more easily. Although managers often do not look at evenness, or equal abundance distribution, of plant communities, it is important to the functioning of ecological systems (Wilsey and Polley 2000, Wilsey and Potvin 2000). We would like to suggest that other managers look at the species richness and distribution of their restorations at a plot level (alpha diversity) as well as the overall site-level results in order to better understand the dynamics of finer scales, the scale experienced by many invertebrates and less mobile organisms.

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APPENDIX: Illustrations