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Traditional tallgrass prairie restoration efforts have focused primarily on planting and managing the dominant species of prairie vegetation. Meanwhile, little is known about techniques for restoring prairie insect species, many of which play important roles in pollination and seed dispersal. The regal fritillary (*Speyeria idalia*) is a prairie endemic butterfly that was once abundant in the Midwest, but now occurs in small, widely-separated populations. The regal and its host plants—bird's-foot violet (*Viola pedata*) and prairie violet (*V. pedatifida*) in Iowa—are found almost exclusively in unplowed native prairie. We have initiated an experiment to restore the regal fritillary at the 5,000-acre Neal Smith National Wildlife Refuge (NWR), which is located just east of Des Moines. Here we report on previous research as well as our progress to date in restoring the regal fritillary.

During 1995-1997, Liesl Kelly and I conducted research showing that most Iowa populations of regals are small (Debinski and Kelly, 1998), and that individual regal fritillaries in Iowa weigh less than regals found in neighboring states (Kelly and Debinski, 1998). We noted that states with higher-weight regal fritillaries had correspondingly larger violet populations, which led us to speculate that limited food supplies may be a factor in the decline and lower weight of regals in Iowa. Leslie Ries (1998) examined the question of rarity in regals by studying their behavior in relation to land use patterns. She found that regals have a low probability of leaving a prairie and that when they do leave a prairie, they typically return within a few minutes. She concluded that the regal may be constrained by such behavior from dispersing and recolonizing fragmented landscapes, such as those found in Iowa. Finally, as a result of my own observations and conversations with others (Wagner, personal communication), I have come to the conclusion that introducing individuals from captive-reared stock is not an option because laboratory rearing of this butterfly is extremely difficult.

During 1998 we began an effort to restore the regal fritillary and its host plant at Neal Smith NWR. The Neal Smith NWR (formerly known as Walnut Creek National Wildlife Refuge) was established in 1991 as a prairie restoration project of the U.S. Fish and Wildlife Service (Drobney, 1994). Most of the property was in agricultural production prior to restoration, although there were some scattered prairie remnants that totaled less than a few hundred acres. We know that the regal fritillary was not present at the refuge prior to its establishment. In 1994, Erwin Klaas (Klaas and Bishop, 1995) conducted a survey of butterflies on the refuge. He found a total of 51 species, but no regals.

We began our work at Neal Smith NWR by setting up experimental plots to test hypotheses regarding the use of fire and bison grazing to restore prairie violet. Specifically, we hypothesized that violets would grow faster and more vigorously in burned and grazed treatments. The violets are short in stature (5-6 inches), so one might expect burning or grazing to have a positive effect on the violets by decreasing competition with other taller plants. Consequently, caterpillars may have a higher survival on violet plots that have been burned or grazed. Testing the effects of burning becomes problematic, however, if the butterflies are introduced prior to burning because regal larvae overwinter as first instars in the leaf litter. As a result, we burned the treatment plots prior to the time that pregnant female butterflies were introduced and will not burn any violet plots once our introductions have been made.

During 1998-1999, we planted 20 plots with 99 violets/plot. We established five plots in each of four areas, each undergoing a different restoration treatment: 1) burned, 2) grazed, 3) unburned in a dense restored planting, and 4) unburned in a sparse restored planting. Around each of the violet plots, we are planting 20 species of nectar plants, such as beebalm (*Monarda fistulosa*), butterfly milkweed (*Asclepias tuberosa*), and pale purple coneflower (*Echinacea pallida*) to provide additional nectar for the butterflies.

Our goal is to introduce pregnant regal females to each of the experimental plots in cages so that they lay their eggs on the violet plots. In most butterfly species, males emerge prior to the females and wait for the females to emerge. Females are mated soon after emergence, so most females can be presumed to be mated a few days post-emergence. During the summer of 2000, we began introducing female regals to the refuge from Ringgold Wildlife Area in Ringgold County, Iowa. This area was within the 38-county ecotype zone that is specified by the refuge for species introductions, and it had a large population of butterflies that year. We netted the butterflies, stored them in a cooler during

Regal fritillary (*Speyeria idalia*) feeds on a prairie blazingstar (*Liatris pycnostachya*) on a remnant prairie in Iowa. Photo courtesy of author

transport, and introduced them to the experimental plots within hours of collection. Once introduced, we kept the butterflies in cages in the violet plots, moving them from plant to plant on a daily basis to maximize egg distribution within the plots. Thus far, we have moved four females to the refuge, and hope to move a few more before the summer 2000 season is over. We intend to survey violets in the spring 2001 for caterpillar abundance.

Our most stunning finding in 2000 has been the appearance of two regals which found their way to the refuge on their own! We observed one in the violet plots as we walked out to check our caged regals. Given that the nearest large population of regals is 100 miles away, perhaps their ability to disperse is not as limited as we previously believed.

In summary, the Neal Smith National Wildlife Refuge offers us an opportunity to test new methods of prairie restoration that include insect species. Our restoration effort is in its infancy. We are starting to see some small indications of success, but our real success will only be measured in a time frame of decades.

ACKNOWLEDGMENTS

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support of Nancy Gilbertson, project manager at Neal Smith NWR; Dan Allen who grew the violet plants from seed; many volunteers who spent their weekends planting and watering violets; faithful assistants in the field such as Scott Bryant, James Pritchard, Erika Saveraid, Scott Mahady, Kristan Price, Jen Bovee, Zoe Pritchard, and Ian Bryant Drobney; and funding from The National Fish and Wildlife Foundation and the Iowa State Experiment Station.

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Spatial Variability of Soil Properties in the Shortgrass Steppe: The Relative Importance of Topography, Grazing, Microsite, and Plant Species in Controlling Spatial Patterns. 1999. Burke, I.C., Natural Resource Ecology Lab, Colorado State University, Fort Collins, Colo. 80523, indy@artemis.cnr.colostate.edu; W.K. Lauenroth, R. Riggle, P. Brannen, B. Madigan, and S. Beard. *Ecosystems* 2(5):422-438.

The results of this study, conducted in the central Great Plains of Colorado, indicate that topography (microsites) and individual plants influence the spatial variability of pools of organic matter found in the soils of arid, shortgrass-steppe ecosystems to a greater extent than either long-term grazing or distinctions between individual plant species. The authors found significantly higher rates of organic matter in the raised hummocks directly beneath blue gama grass (*Bouteloua gracilis*) and plains prickly pear (*Opuntia polyacantha*) than in the soils beneath and between hummocks. Variability in topography had the greatest effect on the most stable pools of organic matter, while microsite greatly influenced pools that turned over relatively rapidly.

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Program Aimed at Reviving Virginia's Native Grasslands. 2000. Carr, D., Bland Experimental Farm, 400 Bland Farm Lane, Unit 2, Boyce, VA 22620. *Bulletin of the Virginia Native Plant Society* 19(1):6.

The restoration of native warm-season grasses, such as big bluestem (*Andropogon gerardi*) and broomsedge (*A. virginicus*), to a 40-acre field on the Bland Experimental Farm is one example of a recent movement to re-establish and protect the dwindling grassland communities of Virginia. The Bland staff plan to reintroduce a fire regimen in order to reduce fescue (*Festuca* spp.) and other non-native species that currently dominate the site. The United States Department of Agriculture Wildlife Habitat Incentives Program, a cost-sharing program available to land owners, has provided a grant to partially fund the project.

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On the Faux Prairie. 2000. Cawthon, R. *The Philadelphia Inquirer*, March 27, 2000: D1, D4.

Cawthon takes readers on a "walk" through a 5,000-acre prairie that the United States Fish and Wildlife Service has spent nine years reconstructing on former farmland at the Neal Smith Wildlife Refuge near Des Moines, Iowa. To date, the agency has planted 2,000 acres with the seed of local prairie species found growing on 2,000 remnant prairies throughout the state. The site is now also home to several of the animal species that populated Iowa's grasslands a century ago, including bison (*Bison bison*) and the northern harrier (*Circus cyaneus*). The agency has already spent \$13 million to seed and manage the prairie and has funds to purchase another 3,600 acres.

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Prairie Restoration in Minnesota: What's Been Done and Plans for the Future. 1999. Hier, R.H., Minnesota Dept. of Natural Resources, Section of Wildlife, 203 West Fletcher, No. 8, Crookston, MN 56716, (218) 281-6063; S.S. Merchant and T.J. Wolfe. *Land and Water* 43(6):9-11.

This article summarizes the results of a survey that the Minnesota Department of Natural Resources sent to state and federal agency personnel in Minnesota and to The Nature Conservancy-Minnesota to determine their restoration goals, accomplishments, and methods. Among the findings: The majority of respondents cite increasing species diversity as the primary goal for restoring a site; most use seed sources that are located within 100 miles of restoration sites; and 75 percent of restoration sites reported were mesic land types, while 20 percent were dry and five percent were wet. Altogether, the represented agencies and organizations had restored 45,000 acres of native

prairie from the 1960s until 1997, with plans to restore at least another 17,500 acres by 2002.

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Population Size and Reproduction in *Phlox pilosa*. 2000. Hendrix, S.D., University of Iowa, Dept. of Biological Sciences, 420 Chemistry Building, Iowa City, IA 52242, stephen-hendrix@uiowa.edu; and J.F. Kyhl. *Conservation Biology* 14(1):304-313.

The fragmentation of prairie habitat can reduce numbers of plant species, which in turn affects the growth and reproduction of even the most common species. In a study of 27 populations of the native prairie phlox—a species that has low seedling emergence and seeds that do not survive long in the seed bank—Hendrix and Kyhl found that smaller populations (less than 1,000 plants) initiated substantially fewer capsules per ramet after flowering and received lower amounts of pollen than larger populations. To ensure viable populations of this species, therefore, restoration sites should be large enough to contain from 1,000 to 2,000 flowering ramets.

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Morphological and Physiological Responses of Perennial Grasses to Longer-Term Grazing in the Pryor Mountains, Montana. 2000. Fahnestock, J.T., Dept. of Renewable Resources, University of Wyoming, Laramie, WY 82071, 307/766-5470, jacef@uwyo.edu; and J.K. Detling. *American Midland Naturalist* 143(2):312-320.

More than a century of grazing by large ungulates has somewhat modified the morphological traits (shorter leaf height and more prostrate angle) of bluebunch wheatgrass (*Pseudoroegneria spicata*) and other dominant grasses growing in the Wild Horse Range of the Pryor Mountains, but Fahnestock and Detling found surprisingly few differences in comparisons of physiological traits (gas exchange and water relations) among grazed and ungrazed grasses. Although these results indicate that grazing in the range is not overly heavy, the authors suggest further study to determine whether changes in physiological mechanisms, or the lack thereof, are related to morphology or to modifications in the microenvironment.

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The Response of Arbuscular Mycorrhizae to Fertilization, Mowing, and Removal of Dominant Species in a Diverse Oligotrophic Wet Meadow. 2000. Titus, J.H., Biosphere 2 Center, 32540 S. Biosphere Road, Oracle, AZ 85623; and J. Leřs. *American Journal of Botany* 87(3):392-401.

Intense fertilization of the wet meadows that occur at low elevations in eastern Europe has dramatically reduced the diversity of an ecosystem that often contains many endangered plant species. Titus and Leřs conducted field experiments in the southwestern Czech Republic to assess how management techniques affect populations of the arbuscular mycorrhizae, an important factor in maintaining the diversity of these meadows. Fertilization treatments significantly reduced the mycorrhizal hyphae and/or vesicles of mycorrhizae on four of the five plant species they examined; mowings increased the hyphae of tormentil (*Potentilla erecta*); and removal of the dominant purple moor grass (*Molinia caerulea*) had no significant effect. The amount of time following treatments significantly affected arbuscular densities on all five species.