



USING LOCAL SEEDS IN PRAIRIE RESTORATION

—*data support the paradigm*—

| Danny J Gustafson, David J Gibson, and Daniel L Nickrent |

Native grasslands throughout the world are becoming increasingly degraded or lost due to human activities. Preservation and conservation efforts assume that remnant communities exist, unfortunately many historical plant communities have either been completely destroyed or reduced to unsustainably small habitats. Prior to European settlement, Illinois constituted approximately 25% (8.9 million ha [22 million ac]) of the North American tallgrass prairie, however, less than 0.01% of high-quality prairie remains today (Robertson and others 1997). The highest quality remaining remnants are often small pioneer cemeteries and linear-shaped railroad rights-of-way (Figure 1). In the spirit of the first tallgrass prairie restoration project established by Dr Aldo Leopold at the University of Wisconsin in 1935, government and nongovernmental organizations and individual citizens have taken an active role in restoring tallgrass

ABSTRACT

Choice among local, non-local, and cultivar seeds for restoring native ecosystems is not purely an academic question—it also has practical consequences. In this article we summarize a series of genetic and competition studies of big bluestem (*Andropogon gerardii* Vitman. [Poaceae]), Indian grass (*Sorghastrum nutans* (L.) Nash. [Poaceae]), and purple prairie clover (*Dalea purpurea* Vent. [Fabaceae]) from remnant and restored Illinois (local) prairies, non-local remnant prairies, and 6 grass cultivars. We found genetic differences between local and non-local seed sources, that large populations do not necessarily have higher genetic diversity relative to small populations, and differences in plant performance could be related to seed source. Although obtaining large quantities of non-local and cultivar grass seeds may be affordable, available, and desirable given the amount of seeds required for prairie restoration, our research indicates genetic and plant performance differences between local and non-local seed sources in all 3 species. Such differences can affect both the short- and long-term success of restoration activities.

KEY WORDS

Andropogon gerardii, *Sorghastrum nutans*, *Dalea purpurea*, remnant and restored grasslands, cultivars, ecotype, Poaceae, Fabaceae

NOMENCLATURE

USDA NRCS (2004)

25

prairies throughout its historical range (Packard and Mutel 1997). Ecological sophistication of restoration practitioners has increased dramatically over the last 3 decades, as evidenced by increased efforts to match ecologically appropriate genotypes to site conditions. Considerations of ecotypic variation, genetic diversity, and introgression of non-local genes into the remnant populations are no longer purely academic concerns but also have practical implications for field restorationists.

In this paper we summarize our genetic and ecological research conducted on big bluestem (*Andropogon gerardii* Vitman. [Poaceae]), Indian

the tallgrass prairie, ours were the first to show genetic structuring and differential performance of 3 dominant plant species across the tallgrass prairie landscape. The grass cultivars tested tended to be more similar to one another than they were to local remnant populations, which was expected given they were developed from plant material originating from Kansas, Nebraska, and Iowa. A surprising result was that individual local restored grass populations were not genetically similar to corresponding local remnant populations within the 100 to 150 km (50 to 100 mi) “local collection range” chosen for preserving the local gene pool. Rather, the genetic similarity of restored populations

restored to remnant local prairies, while grass genetic diversity was not associated with type (remnant, restored, cultivar) or size (small, large) of the prairies. This pattern of genetic diversity is likely affected by the breeding system. Purple prairie clover has an insect-pollinated, mixed mating system, with a 30% to 70% reduction in seed set for self-fertilization relative to outcrossing (Parrish and Bazzaz 1979). Conversely, both grasses possess pre- and post-zygotic incompatibility mechanisms that typically do not result in selfed progeny surviving beyond a single season (Norrman and others 1997; McKone and others 1998), which may help to explain why there were no significant differences in genetic diversity between 2- and 3500-ha-sized (5- and 8000-ac) prairies or the cultivars tested. There was a trend for slightly higher diversity estimates from restored sites relative to remnant sites, which was expected because all restored sites were established with seeds from at least 2 seed sources. A comparison of the genetic diversity estimates from the original seed source to the restored populations would have furthered our understanding as to how much multiple source populations contribute to the genetic diversity of restored outcrossing plant populations.

In addition to genetic differences, the growth form, phenology, and competitive ability among local and non-local seed sources were significantly different. We conducted competition and common-garden experiments on plants from the same seed cohorts used in the genetic studies. Non-local plants from Kansas were typically shorter than the local Illinois plants (Gustafson and others 2002, 2004b) and these morphological and phenological differences persisted in the field (Gustafson and others 2001). In a study of local and non-local restored *A. gerardii* populations established in the 1970s (Figure 2), the non-local populations were shorter (176 cm versus 243 cm [6 ft versus 8 ft]), had higher insect damage to reproductive structures (23% versus 0%), and

A surprising result was that individual local restored grass populations were not genetically similar to corresponding local remnant populations... rather, the genetic similarity of restored populations was often identified more so with the person who established the prairie planting.

grass (*Sorghastrum nutans* Nash. [Poaceae]), and purple prairie clover (*Dalea purpurea* Vent. [Fabaceae]) in Illinois restoration projects (Gustafson and others 1999, 2001, 2002, 2004a, b). All 3 species are perennial long-lived prairie plants and significant components of the prairie ecosystem. Our research focused on 3 basic questions: 1) are local (Illinois) populations genetically different from non-local (Arkansas, Kansas, Nebraska, Iowa) populations; 2) what are the levels of genetic diversity in remnant and restored prairies and commonly used grass cultivars; and 3) are differences in plant performance related to seed source?

Genetic analysis of all 3 species showed differences among local Illinois remnant populations and the non-local populations. This was an important finding because despite hundreds of papers on

was often identified more so with the person who established the prairie planting. Molecular markers allow us to document genetic relationships and diversity among native populations, as well as identify non-local genotype introductions before they can alter the local gene pool. We were unable to sample the original seed source populations the restorationists used because either they could not remember the exact location of the seed source or did not wish to have the location of their source populations revealed. From a native seed business or restoration service perspective, the need to maintain control or access to one’s seed source populations is understandable, although genetic data on the original source populations would help to establish the extent for which “local” genotypes were used.

Purple prairie clover genetic diversity decreased from the large Kansas prairie to

were phenologically behind the populations established from local seeds (Gustafson and others 2001). The established local and non-local populations had maintained their genetic identity for over 20 y despite indications of significant pollen exchange. Testing for differences in fitness between hybrid (local crossed with non-local) relative to within genotype crosses was beyond the scope of our study, however, it was clear that collecting seeds from a local population did not ensure we were collecting the local genotype. If preservation of the local genotype is a priority, then one should not use seeds collected from an area that has local and non-local populations planted juxtaposition to one another. Because vegetative reproduction is far more common in *A. gerardii* (Hartnett 1989) than seedling recruitment in established prairies and the genetic composition of the original planting can have long-term consequences, we strongly recommend documenting the location of the original seed source populations used to establish a restoration project. This documentation requires very little effort, but the potential benefits to our understanding of how to restore our native communities could be far-reaching.

SUMMARY

We now have some answers to our original research questions. First, sources of big bluestem, Indian grass, and purple prairie clover from Illinois are different than those from Kansas, Nebraska, and Iowa. Second, small remnant populations do not necessarily have low genetic diversity relative to larger populations. Therefore, management practices to offset inbreeding depression or founder effects in restoration projects are unwarranted unless one has empirical support for such activities. Third, when growing in Illinois, plants collected from local Illinois sources grew differently than plants collected from non-local sources. We would

have liked to have included multiple common-garden field experiments, sampled more prairies, and sampled the seed source populations used to establish our restored sites. Despite these limitations, our results are fairly consistent and provide empirical support for using local seed sources for prairie restoration projects. We would also like to stress, to all parties active in native plant propagation and restoration, the necessity for documenting the location of local seed sources. This information is extremely valuable to restoration ecologists, conservation geneticists, and managers of native communities within our modern fragmented landscape.

REFERENCES

- Gustafson DJ, Gibson DJ, Nickrent DL. 1999. Randomly amplified polymorphic DNA (RAPD) variation among remnant big bluestem (*Andropogon gerardii* Vitman) populations from Arkansas' Grand Prairie. *Molecular Ecology* 8:1693–1701.
- Gustafson DJ, Gibson DJ, Nickrent DL. 2001. Characterizing three restored *Andropogon gerardii* Vitman (big bluestem) populations established with Illinois and Nebraska seed: established plants and their offspring. In: Berstein N, Ostrander LJ, editors. *Seeds for the future; roots of the past*, Proceedings of the 17th North American Prairie Conference. Mason City (IA): Northern Iowa Area Community College. p 118–127.
- Gustafson DJ, Gibson DJ, Nickrent DL. 2002. Genetic diversity and competitive abilities of *Dalea purpurea* (Fabaceae) from remnant and restored grasslands. *International Journal of Plant Science* 163:979–990.
- Gustafson DJ, Gibson DJ, Nickrent DL. 2004a. Conservation genetics of two co-dominant grass species in an endangered grassland ecosystem. *Journal of Applied Ecology* 41:389–397.
- Gustafson DJ, Gibson DJ, Nickrent DL. 2004b. Competitive relationships of *Andropogon gerardii* (Big Bluestem) from remnant and restored native populations and select cultivated varieties. *Functional Ecology* 18:451–457.



Figure 1. Typical remnant and restored tall grass prairies. (A) Weston Cemetery prairie, McLean County, Illinois; 2-ha (5-ac) remnant prairie. (B) DeSoto railroad prairie, Jackson County, Illinois; 13-ha (33-ac) remnant prairie. (C) Park-Lands Foundation, McLean County, Illinois; 50-ha (123-ac) restored prairie. (D) Konza Prairie Biological Station, Riley County, Kansas; 3487-ha (8617-ac) remnant prairie.

Photos A, B, and C by Danny J Gustafson; photo D by Alice Brandon



Figure 2. Restored tallgrass prairie at Goose Lake Prairie State Natural Area, Grundy County, Illinois. The area was planted in the 1970s and photographed in September 1998. Left of the bag was established with a Nebraska cultivar of *Andropogon gerardii*, whereas an Illinois source was used to the right of the bag.

Hartnett DC. 1989. Density- and growth stage-dependent responses to defoliation in two rhizomatous grasses. *Oecologia* 80:414–420.

McKone MJ, Lund CP, O'Brian JM. 1998. Reproductive biology of two dominant prairie grasses (*Andropogon gerardii* and *Sorghastrum nutans*, Poaceae): male-biased sex allocation in wind-pollinated plants. *American Journal of Botany* 85:776–783.

Norrman GA, Quarin CL, Keeler KH. 1997. Evolutionary implications of meiotic chromosome behavior, reproductive biology, and hybridization in 6x and 9x cytotypes of *Andropogon gerardii* (Poaceae). *American Journal of Botany* 84:201–207.

Packard S, Mutel CF. 1997. The tallgrass restoration handbook for prairies, savannas, and woodlands. Washington (DC): Island Press. 463 p.

Parrish JAD, Bazzaz FA. 1979. Difference in pollination niche relationships in early and late successional plant communities. *Ecology* 60:597–610.

Robertson KR, Anderson RC, Schwartz MW. 1997. The tallgrass prairie mosaic. In: Schwartz MW, editor. Conservation in highly fragmented landscapes. New York (NY): Chapman and Hall. p 55–87.

[USDA NRCS] USDA Natural Resources Conservation Service. 2004. The PLANTS Database, version 3.5. URL: <http://plants.usda.gov> (accessed 8 Nov 2004). Baton Rouge (LA): National Plant Data Center.

AUTHOR INFORMATION

Danny J Gustafson
Assistant Professor
Department of Biology
The Citadel
Charleston, SC 29409
danny.gustafson@citadel.edu

David J Gibson
Professor
dgibson@plant.siu.edu

Daniel L Nickrent
Professor
nickrent@plant.siu.edu

Department of Plant Biology
Southern Illinois University
Carbondale, Illinois 62901-6509