The Schulenberg Prairie: a Benchmark in Ecological Restoration

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EASTERN TALLGRASS PRAIRIE AND THE SCHULENBERG PRAIRIE RESTORATION

Tallgrass prairie once covered much of Midwestern North America, extending from the Great Plains eastward in a narrowing peninsula into southern Wisconsin, Illinois, and adjacent Indiana, with outliers in Michigan and Ohio (Figure 1). Eastern tallgrass prairie covered 66% of the landscape of the Chicago region (Figure 2), McBride & Bowles 2001), where it was floristically diverse, with over 250 characteristic species (Bowles & Jones 2007, Betz 2011). European settlement and subsequent land use have destroyed more than 99 % of this vegetation (White 1978), and restoration is a primary option preventing further loss of its plant diversity, as well as gaining knowledge on how to maintain diversity in naturally occurring remnants. Initiated in 1962, the 16.4 hectare (41 acre) Schulenberg Prairie represents the fourth-oldest Midwestern prairie restoration, following Green Oaks Prairie in 1957 at Knox College (Allison 2002), and the Curtis and Green Prairies at the University of Wisconsin-Madison in 1934 and 1945 (Anderson 2009). Designed to represent the composition and structure of surrounding prairie remnants, The Schulenberg Prairie is a benchmark in ecological restoration.

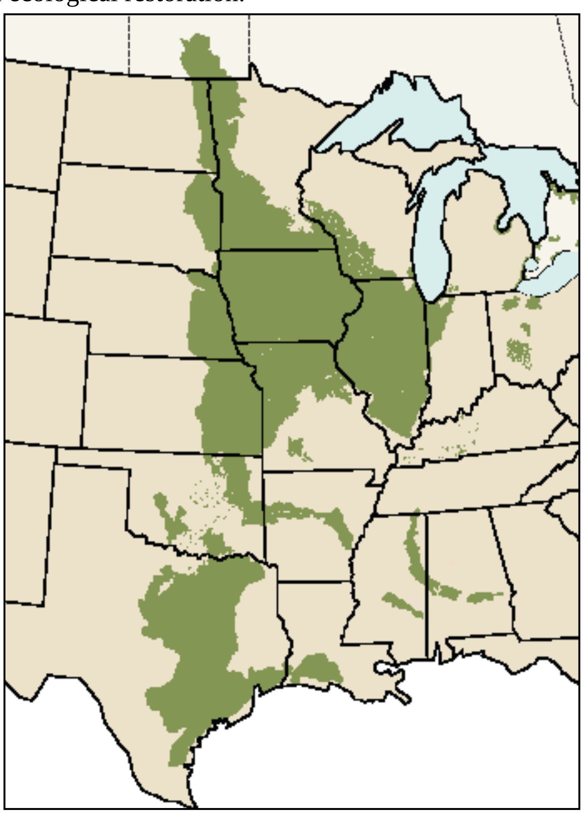

Figure 1. Historic location of tallgrass prairie at the continental scale. Source: http:/ www.tallgrass prairie center. org/media pub. html.

Clarence Godshalk, the Morton Arboretum's first director, and a landscape architect, developed plans to create "a native planting" on farm land acquired in the late 1950's as buffer on the arboretum's western border. He asked assistant propagator Ray Schulenberg to take on this project. Schulenberg (Figure 3) already had a strong interest, and experience, in propagating prairie plants (Schulenberg 1998). He developed restoration goals of replicating the composition, structure and gene pools of prairie remnants within an 80 kilometer (50 mile) radius by studying them with Arboretum taxonomist Floyd Swink, Northeastern Illinois University biologist Robert Betz, and landscape architect David Kropp (Johnson & Rosenthal1992). The Illinois Nature Preserves Commission, and later, the Illinois Natural Areas Inventory, benefited from these studies as they provided information on threatened and representative prairies in need of preservation and further analysis.

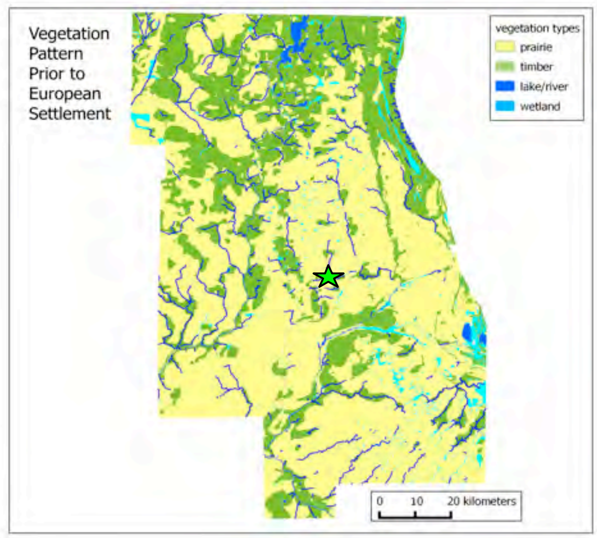

Figure 2. Location of tallgrass prairie within the Chicago region of northeastern Illinois prior to European settlement (McBride 2006). Star indicates location of The Morton Arboretum

The restoration is located at the western edge of a small prairie grove (Figure 4). It ranges in relief from about 700 to 730 feet elevation, with drainage by Willoway Creek into the east fork of the DuPage River. Soils were moderately eroded at higher elevations, but less disturbed at lower elevations. Soil preparation and seed collection began in 1962. Tracts were plowed and disked the fall before planting, and usually rototilled immediately before spring planting (Schulenberg 1998). Seedlings were greenhouse propagated in April (Figure 5) and outplanted in late spring, at the rate of one plant per 0.1 m^2 (1 ft^2). To achieve a natural appearance, naturally co-occurring species were planted in adjacent plots with a 1:1 grass to forb ratio. All legume seeds were inoculated with *Rhizobium* bacteria. Planting occurred in linear blocks along topographic contours (Figure 5). In 1963, 20,000 seedlings representing 70 species were planted, watered and hand weeded, with negligible losses. In 1964, 64,000 seedlings representing an additional 50 species were established. Seed sowing trials on adjacent contours also produced high rates of seedling establishment when watered and hand weeded. These initial plantings took place in an area referred to as "The Acre".

Figure 3. Ray Schulenberg

All plots were burned biennially beginning the year after planting. With help from Arboretum staff and dedicated volunteers, this process continued through the 1960s until 8.3 hectares (21 acres) of diverse prairie vegetation containing 150 native prairie species were established (Schulenberg 1998, Johnson & Rosenthal 1992). The prairie also includes 6.1 hectares (15.1 acres) of un-restored fire-managed grassland that is undergoing succession through colonization by species from adjacent prairie vegetation, as well as 2 hectares (5 acres) of successional grassland managed by mowing. It is adjacent to over 10 hectares (25 acres) of restored and fire-managed savanna and woodland, resulting in a diverse restored ecosystem containing over 300 native plant species. Upon his retirement in 1987, the restoration was named in Ray Schulenberg's honor (Figure 6).

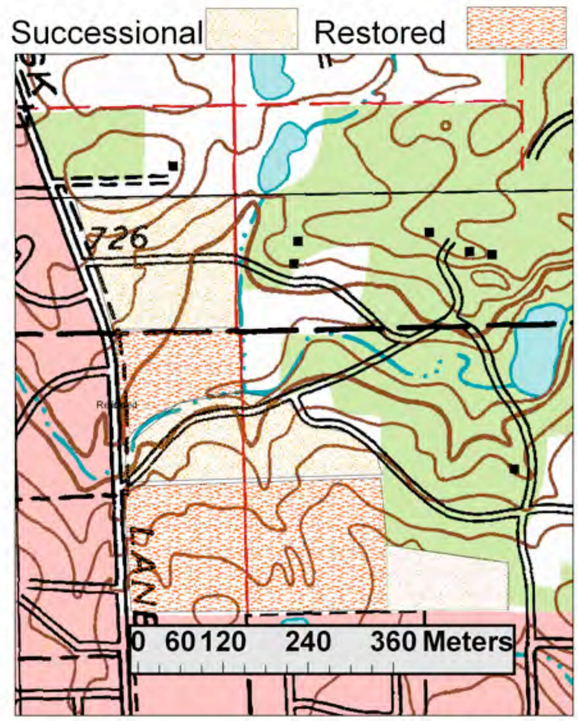

Figure 4. Location of restored and successional prairie at The Morton Arboretum.

Assessment of the Restoration Process

Composition, structure and spatial pattern of the Schulenberg Prairie.

The Schulenberg Prairie flora has been repeatedly censused, and sampled with random transects. It is also monitored by 150 permanent nested ¼, ½ and 1 m^2 plots established on a 30 m (100 ft) grid. In 2012, 132 native species occurred in the grid plots. In these plots, 23 species accounted for two-thirds of the relative abundance of all species (Table 1). Dominant graminoid species were the warm season grasses little bluestem (*Schizachyrium scoparius*), Indian grass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), prairie dropseed (*Sporobolus heterolepis*), and the sedge *Carex bicknellii*. Dominant forbs included the spring-flowering white false indigo (*Baptisia alba*) and blue-eyed grass (*Sisyrinchium albidum*), as well as rigid goldenrod (*Solidago rigida*), tall tickseed (*Coreopsis tripteris*) and white prairie clover (*Dalea candida*). Four of the dominant species were also nitrogen fixing legumes. The alien bluegrasses *Poa compressa* and *P. pratensis* and the invasive native shrub gray dogwood (*Cornus racemosa*) were also dominant species. These species were not introduced, but either persisted or invaded the restored prairie.

Small-scale species richness provides a key metric for evaluating differences among prairie remnants and ranking their quality (Bowles & Jones 2006). Native species richness per square meter plot varied significantly across The Schulenberg Prairie (Figure 7). This metric averaged 13.3 (0.7 se) species per plot in a 2 hectare (5 acre) area restored in 1963-1967, 9.7 (0.3 se) species in other restored areas and 7.2 (0.3 se) species in successional vegetation (Figure 8). Conversely, alien richness was four times as abundant in successional vegetation, reaching 1.6 (0.2) species per plot.

Table 1. Abundance of dominant species of the Schulenberg Prairie. Functional groups: C4 = grasses using the C4 photosynthetic pathway, C3 = grasses and sedges using the C3 photosynthetic pathway, SP = spring flowering, SU = summer flowering, N = nitrogen-fixing, W = woody. Nomenclature follows Flora of North America (http//flora northamerica.org/) where treatments are completed.

Group	Species	Frequency	Rel. freq.
C4	*Schizachyrium scoparius*	71.03	7.01
C4	*Sorghastrum nutans*	58.62	5.79
C4	*Andropogon gerardii*	24.83	2.45
C4	*Sporobolus heterolepis*	16.55	1.63
C3	*Carex bicknellii*	29.66	2.93
C3/ALIEN	*Poa compressa*	28.97	2.86
C3/ALIEN	*Poa pratensis*	20	1.97
SPN	*Baptisia alba*	15.86	1.57
SP	*Sisyrinchium albidum*	13.79	1.36
SU/N	*Lespedeza capitata*	30.34	3
SU	*Solidago rigida*	68.97	6.81
SU	*Coreopsis tripteris*	44.83	4.42
SU/N	*Dalea candida*	37.93	3.74
SU	*Ratibida pinnata*	27.59	2.72
SU	*Symphyotyrichum ericoides*	25.52	2.52
SU	*Monarda fistulosa*	25.52	2.52
SU	*Silphium integrifolium*	25.52	2.52
SU	*Solidago altissima*	20	1.97
SU/N	*Dalea purpureum*	17.24	1.7
SU	*Veronicastrum virginicum*	16.55	1.63
SU	*Coreopsis palmate*	14.48	1.43
SU	*Echinacea pallida*	14.48	1.43
W	*Cornus racemosa*	24.14	2.38
	TOTAL		66.36

Species functional groups, which perform different ecological functions or differ in other characteristics, varied in species richness among the restoration and successional vegetation plots (Figure 9). Overall, summer flowering grasses, which use the C4 photosynthetic pathway, were twice as abundant as early flowering grasses grasses and sedges, which use the C3 photosynthetic pathway. These groups did not differ in richness among the different restoration areas. Summer flowering herbs were the dominant group and made the greatest contribution to greater species richness in the higher quality restoration. Spring flowering forbs were four times as abundant in the higher quality restoration, while nitrogen-fixing species had lower richness in successional vegetation. Both alien and woody species had greater representation in successional vegetation. Ray Schulenberg knew that the initially restored 2 ha area represented his best effort toward replicating the composition and structure of native prairie (Schulenberg 1998). One reason may be that this area received more intensive work, including a greater number of species as well as outplanting and sowing at higher densities than in other areas. Later restoration work in the prairie relied heavily on seed harvest from the older tracts, which may have limited species representation. These results also illustrate that successional establishment among functional groups may differ from the enforced order of species establishment used in the restoration.

Figure 5. Plot layout, propagating, planting and weeding.

Figure 6. Dedication of The Schulenberg Prairie.

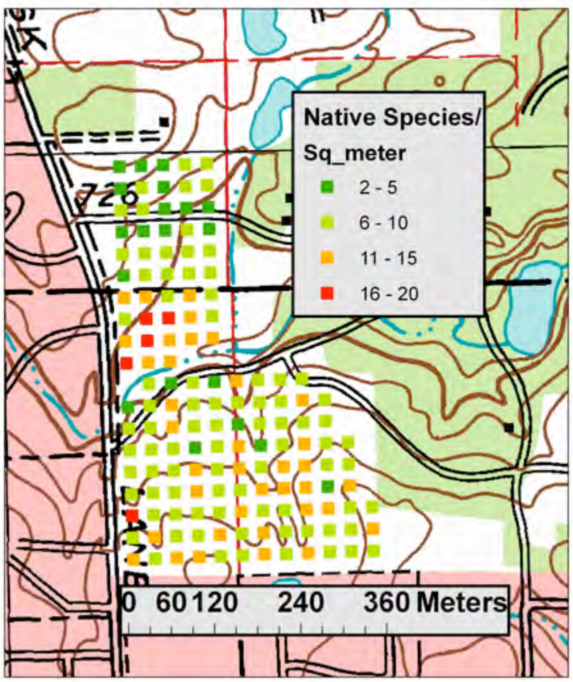

Figure 7. Distribution of species richness in the Schulenberg Prairie.

Drainage and soil characteristics are well known for their influence on the distribution of species and species richness (Curtis 1959). Individual species tend to sort along moisture gradients, with greater species richness occurring in areas of intermediate drainage and herbaceous biomass (Bowles & Jones 2007, Bowles & Jones *in press*). The Schulenberg Prairie soils show an expected significant relationship between elevation, soil moisture and soil carbon (Figure 10). However, the distribution of species richness and biomass do not yet appear to be related to these conditions. Rather, they correspond to restoration age, with greater biomass and native richness in older higher quality vegetation (Figure 8), and support the findings of Tillman et al. (2001) that vegetation productivity and richness are positively correlated. Individual species also do not display strong sorting along the prairie elevational gradient. As a result, vegetation in the Schulenberg Prairie still reflects the original restoration pattern. Lower species richness in adjacent successional vegetation also indicates that restoration can accelerate vegetation establishment compared to natural succession.

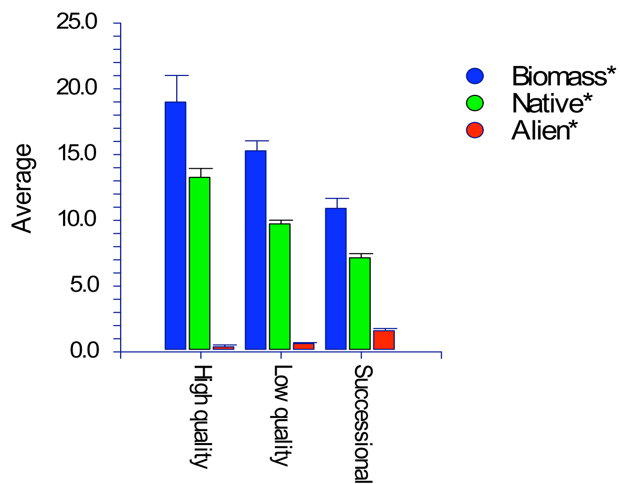

Figure 8. Biomass (g/10), and native and alien species richness/m^2 in restored and successional vegetation in The Schulenberg Prairie. Asterisk (*) indicates significant variation among vegetation types.

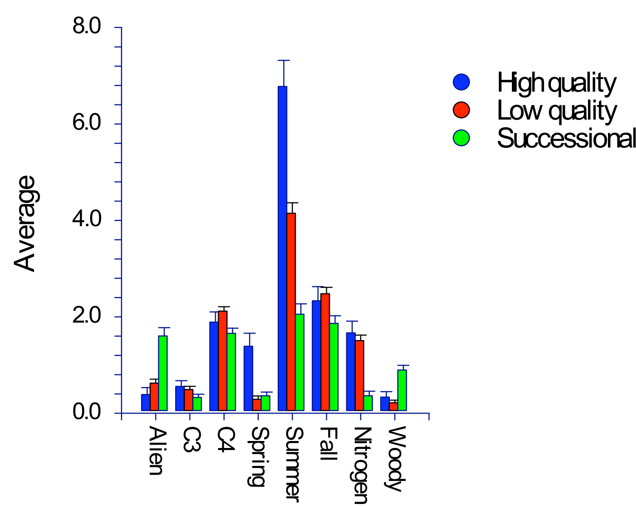

Figure 9. Comparision of species richness/m^2 among functional groups in high and low quality restored prairie and in successional prairie vegetation in The Schulenberg Prairie.

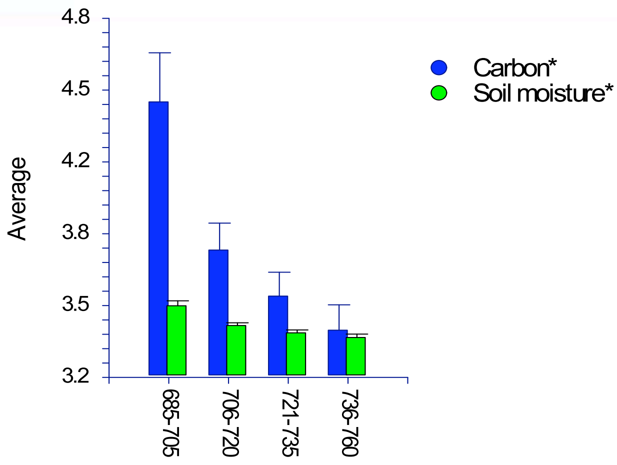

Figure 10. Distribution of soil carbon % by weight in 0-15 cm depth, and soil moisture (Ln %) across an elevation class gradient in The Schulenberg Prairie. Asterisk (*) indicates significant variation across the gradient

How well does the Schulenberg Prairie represent surrounding prairie remnants?

To further clarify the level of success achieved in the restoration, the higher quality area of the Schulenberg Prairie was compared with data collected from 18 mid and late-successional mesic prairie remnants located in the Chicago region. These comparisons demonstrate that restoration success was scale dependent (Figure 11). At the smallest (alpha) scale, measured by ¼-m^2 plots, the average number of native species per plot in the Schulenberg Prairie is similar to that of late-successional (undisturbed) and mid-successional (historically disturbed) prairie remnants. At a larger (gamma) scale, measured by the cumulative number of species sampled, the Schulenberg Prairie has lower richness than late-successional prairie and is similar to mid-successional prairie. These data indicate that Ray Schulenberg was successful in restoring the high alpha-scale species richness characteristic of remnants, but not their higher gamma-scale richness. The lower gamma diversity probably resulted from multiple factors, including selection imposed through choice of species for seed collection, availability of seeds from different species and environmental factors affecting seedling establishment.

Comparisons of species richness within functional groups between the higher quality Schulenberg Prairie restoration and remnants reveal that, after 50 years, the restoration process resulted in over or under-representation of different groups (Figure 12). C3 species were under-represented, possibly due in part to focus on *Carex bicknellii* as a representative prairie sedge. Spring herbs were also under represented, with *Comandra umbellata* the most abundant species. Ray Schulenberg was aware of this discrepancy (Schulenberg 1998), which he attributed to the difficulty of collecting seeds from short statured spring flowering herbs in tallgrass vegetation, as well as their greater difficulty in propagation and establishment. C4 species richness tended to be equally represented in the Schulenberg Prairie and in remnants. Summer forb species are under-represented in comparison to remnants, with over-representation of *Monarda fistulosa*, *Coreopsis tripteris*, *Symphyotyrichum ericoides* and *Veronicastrum virginicum*. As over 200 forb species occur in native prairies, and summer forbs dominate this group (Betz 2011), there was probably great difficulty in making seed collections that would represent this large number of species.

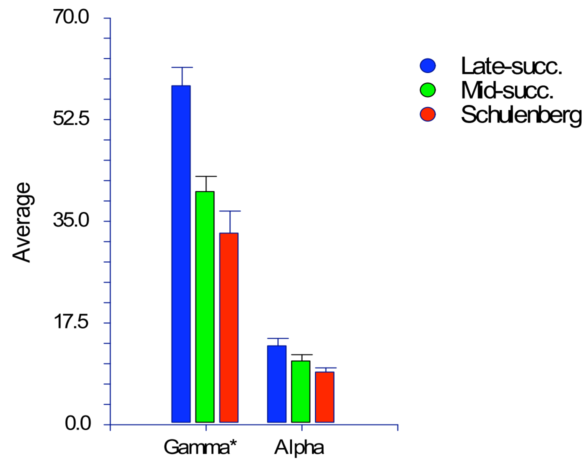

Figure 11. Comparison of alpha (1/4m^2)- and gamma-scale native species richness among late- and mid-successional prairie remnants and high quality vegetation in The Schulenberg Prairie. Asterisk (*) indicates significant difference within each scale of measurement.

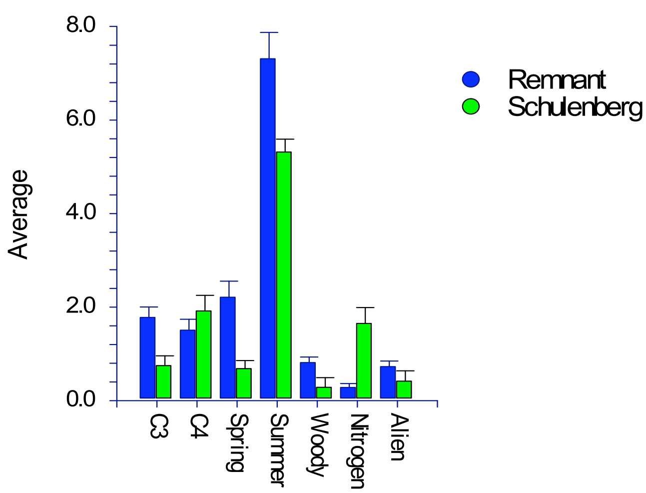

Figure 12. Comparison of species richness/1/4m^2 among functional groups in late-successional prairie remnants and high quality vegetation in the Schulenberg Prairie.

Ray Schulenberg may have focused on representing nitrogen-fixing species, as they are greatly over-represented, primarily due to greater richness of the herbs *Dalea candida, P. purpureum*, *Desmodium illinoense* and *Lespedeza capitata*, as well as the nitrogen-fixing shrub *Amorpha canescens*. These species also may have spread under the aggressive fire management regime, which would have selected for nitrogen-fixing species by limiting available nitrogen (Towne & Knapp 1996). Native woody species such as *Rosa carolina* appear to be under represented and replaced by the more invasive *Cornus racemosa*. This may represent both under selection, as well as invasion by the latter species.

Current use of the Schulenberg Prairie

Research applications

Ray Schulenberg conducted his work during an era that lacked replicated experimental design approaches to restoration (Anderson 2009). Nevertheless, the Schulenberg Prairie represents a benchmark for restoration success achieved through high density outplanting and seed sowing, and also supports conclusions from the Curtis Prairie that long-term results may be independent of either planting or seed sowing (Anderson 2009). Effects of time and succession on the current structure of the prairie are poorly understood due to lack of sampling data representing the early stages of the restoration. Even in the 1960s, Ray observed that parts of the prairie resembled his vision of prairie remnants, yet he also observed rapid succession into unplanted parts of the prairie. Nevertheless, current comparisons indicate differences in functional group richness between restored and successional vegetation.

Restoration theory suggests that species richness in fire-managed restorations is limited by dominance of C4 grasses and small species pools, and that disturbance to dominant grasses, such as by grazing or seasonal variation in fire, may be required to reduce competitive dominance in productive habitats (Howe 1999, Foster et al. 2011, Foster et al. 2004, McCain et al. 2010). Although there is evidence from western tallgrass prairie that similar processes may limit plant diversity in frequently burned native prairie (e.g., Collins and Calabrese 2012), eastern tallgrass prairie may be more fire-dependent (Bowles & Jones 2004, Bowles & Jones *in press*). Restoration of keystone parasitic species that reduce grass competition also may contribute to high diversity (Henderson 2003). Ray Schulenberg apparently overcame these factors by using high-density planting and seed sowing to saturate small scale species richness. However, historic agricultural use in the former farmland used for the restoration may have reduced nutrient availability and competition from C4 grasses. Successional theory suggests delayed establishment of late-successional prairie species in restorations, requiring a chronological, or staged, approach to establish ecologically stable late-successional prairie vegetation (Betz 1986, Schramm 1992). Ray Schulenberg also forced succession, as he established many species thought to have delayed establishment in restorations, supporting an initial floristics restoration model (e.g. Aschenbach & Kindscher 2003).

The Schulenberg Prairie has been managed with a high-frequency fire regime, with biennial fire from 1963-1980, and annual burning thereafter. Current research focuses on understanding the relationship between below-ground soil processes, productivity, and species diversity, as well as ongoing plant succession and vegetation change. Understanding how species and species richness respond to repeated burning, and whether it stabilizes this vegetation will be critical for managing fire-adapted vegetation. The Schulenberg Prairie also serves as a replicate for regional comparisons among other restorations, as well as remnants. Understanding how well restoration practices mirror different successional stages in remnants may provide information that can facilitate prairie restoration and management. This information may be critical as climate change and other factors result in both immigration and emigration of species, and cause shifts toward floristically novel and potentially unstable plant communities that lack historic benchmarks. In turn, understanding how climate change may drive change in ecological processes that affect species composition will also be critical information that can be applied to prairie restoration and management in the 21st century.

Education and Public Use

The Schulenberg Prairie is an important educational resource (Johnson & Rosenthal 1992). The Arboretum educational program uses the site for class instruction in taxonomy, ecology and restoration. Local colleges also use the site as a field trip destination for similar purposes. The site is also used as a resource template by land managers, restoration ecologists and landscape architects. It is also used as a inspirational resource by individual visitors, special interest groups, photographers and writers.

Acknowledgments

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REFERENCES

Allison, SK, 2002. When is a restoration successful? Results from a 45 year-old tallgrass prairie restoration. *Ecological Restoration* 20:10-17.

Anderson, R. 2009. History and Progress of Ecological Restoration in Tallgrass Prairie. Chapter 13 in Taft, J. & C. Warwick, (eds) Canaries in the Catbird Seat, The Past, Present, and Future of Biological Resources in a Changing Environment *INHS Special Publication 30.*

Aschenbach, TA & K Kindscher. 2003. Comparison of planting treatments in a tallgrass prairie restoration. Pages 44-48 in: S Fore (ed.), Proceedings of the Eighteenth North American Prairie Conference. Truman State University. Kirksville, Missouri.

Betz, R. 1986. One decade of research in prairie restoration at the Fermi National Accelerator Laboratory (Fermilab) Batavia, Illinois. Pages 179–185 *in* G Clambey and R Pemble, eds. The prairie: past, present and future, Proceeding of the Ninth North American Prairie Conference. Tri-College University Center for Environmental Studies, North Dakota State University, Fargo.

Betz, RF. 2011. The Prairies of the Illinois Country. DMP Inc. Dave Martin, Westmont, Illinois.

Bowles, M & M Jones. 2004. Long-term changes in Chicago region prairie vegetation in relation to fire management. Chicago Wilderness Journal 2(2):7-16.

Bowles, M & M Jones. 2006. Testing the efficacy of species richness and floristic quality assessment of quality, temporal change and fire effects in tallgrass prairie natural areas. Natural Areas Journal 26:17-30.

Bowles, M & M Jones. 2007. The prairie-wetland vegetation continuum in the Chicago region of northeastern Illinois. Ecological Restoration 25 (1):29-38.

Bowles, M & M Jones. *In press*. Repeated burning of eastern tallgrass prairie increases richness and diversity, stabilizing late successional vegetation. Ecological Applications.

Collins, SL & LB Calabrese. 2012. Effects of fire, grazing and topographic variation on vegetation structure in tallgrass prairie. Journal of Vegetation Science 23:563-575.

Curtis, JT. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison.

Foster, BL, TL Dickson, CA Murphy, IS Karel & VH Smith. 2004. Propagule pools mediate community assembly and diversity-ecosystem regulation along a grassland productivity gradient. Journal of Ecology 92:435-339.

Foster, BL., EJ Questad, CD Collins, CA. Murphy, TL Dickson and VH Smith. 2011. Seed availability constrains plant species sorting along a fertility gradient. Journal of Ecology 99:473-481.

Henderson, RA. 2003. Are there keystone plant species driving diversity in Midwest prairies? Pages 63-74 *in:* S. Fore (ed.), Proceedings of the Eighteenth North American Prairie Conference. Truman State University. Kirksville, Missouri.

Howe, H. 1999. Dominance, diversity and grazing in tallgrass prairie restoration. Ecological Restoration 17:59-64.

Johnson, C & M Rosenthal. 1992. Thirty years of prairie reconstruction. The Morton Arboretum Quarterly.

McBride, J. 2006. Vegetation map of the Chicago region as mapped by the Public Land Survey 1821-1845 (http://plantconservation.us/plsmap.phtml).

McCain, KNS, SG Baer, JM Blair & GWT Wilson. 2010. Dominant grasses suppress local diversity in restored tallgrass prairie. Restoration Ecology 18:40-49.

Schramm, P. 1992. Prairie restoration: a twenty-five year perspective on establishment and management. Pages. 69-177. *In*: DD Smith and CA Jacobs (eds.). Proceedings of the Twelfth North American Prairie Conference. University of Northern Iowa, Cedar Falls.

Schulenberg, R. 1970. Summary of Morton Arboretum prairie restoration work, 1963–1968. Pages 45–46 *in* P. Schramm. (ed.) Proceedings of a symposium on prairie and prairie restoration. Knox College, Galesburg, IL.

Schulenberg, R. 1998. Natural areas management and the prairie plantings at The Morton Arboretum. Introduction to Natural Areas Management Course. The Morton Arboretum.

Swink, F. & G Wilhelm. 1994. Plants of the Chicago Region. Indiana Academy of Science, Indianapolis.

Tillman, D, PB Reich, J Knops, D Wedin, T Mielke & C Lehman. 2001. Diversity and productivity in a long-term grassland experiment. Science 294:843-845.

Towne, EG & AK Knapp. 1996. Biomass and density responses in tallgrass prairie legumes to annual fire and topographic position. American Journal of Botany 83:175-179.

White, J. 1978. Illinois natural areas inventory technical report, volume I, survey methods and results. University of Illinois at Urbana, Department of Landscape Architecture and Natural Land Institute, Rockford, Illinois.

Appendix I. Plant Species Recorded from The Schulenberg Prairie

Nomenclature follows Flora of North America (http//flora northamerica.org/) where treatments are completed.

Acer negundo L.
Acer saccharum Marshall
Achillea millefolium L.
Ageratina liebmannii (Sch.Bip. ex Klatt) R.M.King & H.Rob.
Agrimonia gryposepala Wallr.
Allium canadense L.
Allium cernuum Roth
Ambrosia artemisiifolia L.
Ambrosia trifida L.
Amorpha canescens Pursh
Amorpha fruticosa L.
Ampelamus albidus (Nutt.) Britton
Amphicarpaea bracteata (L.) Fernald
Andropogon gerardii Vitman
Anemone canadensis L.
Anemone cylindrica A. Gray
Anemone patens var. multifida Pritz.
Anemone quinquefolia L.
Anemone virginiana L.
Antennaria neglecta Greene
Antennaria plantaginifolia (L.) Richardson
Apios americana Medik.
Apocynum cannabinum L.
Apocynum sibiricum Jacq.
Arctium minus (Hill) Bernh.
Arisaema triphyllum (L.) Schott
Arnoglossum atriplicifolium (L.) H.Rob.
Arnoglossum plantagineum Raf.
Asclepias meadii Torr. ex A. Gray
Asclepias purpurascens L.
Asclepias syriaca L.
Asclepias tuberosa L.
Asclepias verticillata L.
Asparagus officinalis L.
Astragalus canadensis L.
Baptisia alba (L.) Vent.
Baptisia leucophaea Nutt.
Barbarea vulgaris W.T. Aiton
Bouteloua curtipendula (Michx.) Torr.
Bromus inermis Leyss.
Caltha palustris L.
Calystegia sepium var. sepium
Campanula americana L.
Carex bicknellii Britton
Carex blanda Dewey
Carex gravida L.H. Bailey
Carex molesta Mack.
Ceanothus americanus L.
Cirsium discolor (Muhl. ex Willd.) Spreng.
Comandra umbellata (L.) Nutt.
Coreopsis lanceolata L.
Coreopsis palmata Nutt.
Coreopsis tripteris L.
Cornus racemosa Lam.
Crataegus mollis (Torr. & A. Gray) Scheele
Dalea candida Willd.
Dalea purpurea Vent.
Desmodium illinoense A. Gray
Dichanthelium leibergii (Vasey) Freckmann
Dodecatheon meadia L.
Echinacea pallida (Nutt.) Nutt.
Elymus canadensis L.
Elymus hystrix L.
Erigeron annuus (L.) Desf.
Erigeron philadelphicus L.
Erigeron strigosus Muhl. ex Willd.
Eryngium yuccifolium Michx.
Erythronium albidum Nutt.
Eupatorium altissimum L.
Euphorbia corollata L.
Galium boreale L.
Gentiana flavida A. Gray
Gentiana puberulenta J.S. Pringle
Gentiana quinquefolia var. occidentalis (A. Gray) Hitchc.
Geum triflorum Pursh
Glechoma hederacea L.
Hackelia virginiana (L.) I.M. Johnst.
Helianthus decapetalus L.
Helianthus grosseserratus M.Martens
Helianthus mollis Lam.
Helianthus occidentalis Riddell
Helianthus strumosus L.
Heliopsis helianthoides (L.) Sweet
Hesperostipa spartea (Trin.) Barkworth
Heuchera richardsonii R. Br.
Hieracium caespitosum Dumort.
Hydrophyllum virginianum L.
Hypoxis hirsuta (L.) Coville
Iliamna remota Greene
Impatiens capensis Meerb.
Iris virginica var. shrevei (Small) E.S.Anderson
Juglans nigra L.
Juncus tenuis Willd.
Koeleria macrantha (Ledeb.) Schult.
Lactuca canadensis L.
Lathyrus venosus Muhl. ex Willd.
Lespedeza capitata Michx.
Liatris aspera Michx.
Lilium michiganense Farw.
Lithospermum canescens (Michx.) Lehm.
Lonicera maackii (Rupr.) Maxim.
Lotus corniculatus L.
Lysimachia ciliata L.
Maianthemum stellatum (L.) Link
Matteuccia struthiopteris (L.) Tod.
Melilotus albus Medik.
Melilotus officinalis (L.) Lam.
Menispermum canadense L.
Monarda fistulosa L.
Morus alba L.
Napaea dioica L.
Oenothera biennis L.
Oenothera pilosella Raf.
Opuntia humifusa (Raf.) Raf.
Ostrya virginiana (Mill.) K. Koch
Oxalis stricta L.
Oxalis violacea L.
Oxypolis rigidior (L.) Raf.

Panicum virgatum L.
Parthenium integrifolium L.
Parthenocissus quinquefolia (L.) Planch.
Pastinaca sativa L.
Pedicularis canadensis L.
Penstemon digitalis Nutt. ex Sims
Persicaria pensylvanica (L.) M. Gómez
Phalaris arundinacea L.
Phleum pratense L.
Phlox glaberrima L.
Phlox pilosa L.
Phryma leptostachya L.
Physostegia virginiana var. arenaria Shimek
Plantago lanceolata L.
Plantago major L.
Plantago rugelii Decne.
Poa compressa L.
Poa nemoralis L.
Poa pratensis L.
Podophyllum peltatum L.
Polemonium reptans L.
Polygala senega L.
Polygonatum canaliculatum (Willd.) Pursh
Polygonum virginianum L.
Polytaenia nuttallii DC.
Populus deltoides W. Bartram ex Marshall
Potentilla arguta Pursh
Potentilla fruticosa L.
Potentilla recta L.
Potentilla simplex Michx.
Prunella vulgaris var. lanceolata (W.P.C. Barton) Fernald
Prunus pumila L.
Prunus serotina Ehrh.
Prunus virginiana L.
Psoralidium tenuiflorum (Pursh) Rydb.
Pycnanthemum virginianum (L.) B.L. Rob. & Fernald
Quercus coccinea Münchh.
Quercus macrocarpa Michx.
Ranunculus rhomboideus Goldie
Ranunculus septentrionalis Poir.
Ratibida pinnata (Vent.) Barnhart
Rhamnus cathartica L.
Rhus glabra L.
Rosa blanda Aiton
Rosa carolina L.
Rosa multiflora Thunb.
Rosa setigera Michx.
Rubus allegheniensis Porter
Rubus occidentalis L.
Rubus pensilvanicus Poir.
Rudbeckia hirta L.
Ruellia humilis Nutt.
Rumex crispus L.
Salix fragilis L.
Salix humilis Marshall
Salix interior Rowlee
Sambucus canadensis L.
Sanguisorba canadensis L.
Sanicula gregaria E.P. Bicknell
Schizachyrium scoparium (Michx.) Nash
Silene latifolia Poir.
Silene stellata (L.) W.T. Aiton
Silphium integrifolium Michx.
Silphium laciniatum L.
Silphium perfoliatum L.
Silphium terebinthinaceum Jacq.
Sisyrinchium albidum Raf.
Smilacina racemosa (L.) Desf.
Smilax lasioneura Hook.
Solanum dulcamara L.
Solidago altissima L.
Solidago juncea Aiton
Solidago nemoralis Aiton
Solidago ptarmicoides (Torr. & A.Gray) B.Boivin
Solidago riddellii Frank ex Riddell
Solidago rigida L.
Solidago speciosa A.Gray
Sorghastrum nutans (L.) Nash
Spartina pectinata Link
Sporobolus heterolepis (A. Gray) A. Gray
Symphyotrichum ericoides (L.) G.L.Nesom
Symphyotrichum laeve (L.) Á.Löve & D.Löve
Symphyotrichum lanceolatum (Willd.) G.L.Nesom
Symphyotrichum lateriflorum (L.) Á.Löve & D.Löve
Symphyotrichum novae-angliae (L.) G.L.Nesom
Symphyotrichum pilosum (Willd.) G.L.Nesom
Symphyotrichum undulatum (L.) G.L.Nesom
Taraxacum officinale F.H.Wiggers
Tephrosia virginiana (L.) Pers.
Teucrium canadense L.
Thalictrum dasycarpum Fisch. & Avé-Lall.
Thalictrum revolutum DC.
Toxicodendron radicans (L.) Kuntze
Tradescantia ohiensis Raf.
Tragopogon pratensis L.
Trifolium hybridum L.
Trifolium pratense L.
Trillium recurvatum L.C. Beck
Ulmus americana L.
Ulmus pumila L.
Ulmus rubra Muhl.
Valeriana ciliata Torr. & A. Gray
Verbascum blattaria L.
Verbascum thapsus L.
Verbena hastata L.
Verbena urticifolia L.
Veronicastrum virginicum (L.) Farw.
Viburnum recognitum Fernald
Vicia americana Muhl. ex Willd.
Viola affinis Leconte
Viola pedatifida G. Don
Viola pubescens Aiton
Viola sagittata Aiton
Viola sororia Willd.
Vitis riparia Michx.
Wulfenia bullii (Eaton) Barnhart
Zizia aptera (A. Gray) Fernald
Zizia aurea Koch