ERIGENIA

Number 25
Spring 2012

Journal of the
Illinois Native Plant Society

ERIGENIA

Number 25, Spring 2012

The Illinois Native Plant Society Journal

The Illinois Native Plant Society is dedicated to the preservation, conservation, and study of the native plants and vegetation of Illinois.

MEMBERSHIP

Yearly membership includes a subscription to *Erigenia* and the quarterly newsletter, *Harbinger*. For more information, visit our website at www.ill-inps@org or write to:

Illinois Native Plant Society
Forest Glen Preserve
20301 E. 900 North Road
Westville, IL 61883
e-mail: ilnps@aol.com

ERIGENIA is named for *Erigenia bulbosa* (Michx.) Nutt. (harbinger of spring), one of our earliest blooming woodland plants. The first issue was published in August, 1982.

(ISSN 8755-2000)

COVER ILLUSTRATION: Drawing of Hall's Bulrush (*Schoenoplectus hallii*) and a damselfly (*Argia apicalis*) used for size comparison by Polly Danforth.

LETTER FROM THE EDITOR:

Greetings fellow plant enthusiasts,

Discovering and recording ongoing changes in the Illinois flora is now more important than ever. This is a time of unprecedented challenges to the environment including climate change, biodiversity loss, and invasive species. It is a privilege as well as obligation to help document the native flora of our state. Nearly half of the national workforce with botanical expertise will retire in the next ten years. The Illinois Department of Natural Resources has half the number of employees it had ten years ago and a large percentage of the remaining employees are eligible for retirement in the next five years. Those of you who are botanically trained can contribute to the future by continuing to submit scientific articles to Erigenia specifically to document 1) new distribution records for either the state or specific counties; 2) rediscoveries of species thought to be extirpated; 3) the spread of non-native species; and 4) contribute to a centralized tracking for new species and rediscoveries.

Tracy Evans, Editor

ERIGENIA

NUMBER 25, SPRING 2012

TABLE OF CONTENTS

About Our Authors

Patricia K. Armstrong has a B.A. in Biology from North Central College in Naperville and an M.S. in Botany-Ecology from the University of Chicago. She has been a traditional and non-traditional educator for many years. She managed the Schulenburg Prairie. She now runs a private consulting business, Prairie Sun Consultants, from her passive solar electric home in Naperville.

Roger Beadles is the owner of Beadles Barrens Nature Preserve. He is a botanist whose interests include restoration of natural communities, photography and monitoring populations of rare plants.

Michael Blackowicz is a graduate student at Eastern Illinois University. He is a Resident Intern in the IDNRs' Division of Natural Heritage. He is responsible for maintaining and improving healthy populations of non-game wildlife. In order to pursue this objective, he spends most of his time restoring native habitats and surveying threatened and endangered species.

Janice M. Coons is a botany professor at Eastern Illinois University and is active in the Illinois State Academy of Science and the Botanical Society of America. She teaches classes including plant physiology and horticulture. Her research involves reproductive biology of rare species from the Midwest and Florida with restoration applications as well as propagation of native species for use in landscaping.

Polly Danforth is a lifelong lover of nature and friend to INPS. Originally from southern Illinois, she now resides in rural Sangamon County where she is a self-employed graphic designer.

John E. Ebinger is emeritus professor of botany at Eastern Illinois University. His research focuses on the structure and composition of forest, glade and sand prairie communities in Illinois as well as the tropical genus *Acacia*.

Bob Edgin is a field representative for the Illinois Nature Preserves Commission. His research focuses on the structure and composition of forest and prairie communities and population dynamics of endangered plant species within Illinois nature preserves.

Marissa Grant is the Land Stewardship Director at the Douglas-Hart Nature Center located in Mattoon, Illinois. She works on conservation and restoration of prairie, woodland and wetland habitats. She received her Bachelors and Masters degrees from Eastern Illinois University and is an active member of the Illinois State Academy of Science, Botanical Society of America and the Illinois Native Plant Society.

Paul D. Kilburn was formerly a professor at Principia College, Elsah, is now retired and is President of the Jefferson County Nature Association in Colorado. His major interest is conservation and preserving high plains grasslands.

Paul Marcum is an academic professional/wetland plant ecologist with the Illinois Natural History Survey, University of Illinois' Institute of Natural Resource Sustainability. His research focuses on the flora and plant community quality and composition within our remaining high quality natural areas.

April McDonnell received her M.S. in Biological Sciences from Eastern Illinois University in 2006. Her graduate work focused on the Illinois state endangered plant species *Iliamna remota*. She conducted field work and physiological research on the reproductive physiology of this species.

Loy R. Phillippe is a collection manager for the vascular plants and fungi at the Illinois Natural History Survey. His primary duties include herbarium computerization, specimen collection and preparation and the daily operations of the herbarium. Loy earned a B.S. and M.S. in botany from Eastern Illinois University and a Ph.D. in plant taxonomy from the University of Tennessee.

John E. Schwegman is a nature conservationist. He is retired from the Illinois Department of Natural Resources where his career included both natural area preservation and native plant conservation.

ERIGENIA, Number 25, Spring 2012, pp 3–7

ELIHU HALL ILLINOIS BOTANIST AND PLANT EXPLORER OF THE WESTERN UNITED STATES

John E. Schwegman[1]

Nineteenth century Illinois probably had more than its share of resident botanists collecting and studying the native flora. For the most part, these were not professionally trained botanists but "avocational" students of plants who pursued their studies in their spare time. Many of these were trained as physicians such as Samuel Mead of Augusta, Frederick Brendel of Peoria, George Vasey at Ringwood, and Jacob Schneck at Mt. Carmel. Physician training in those days included introduction to some medicinal plants which may have contributed to their interest in the flora. E. J. Hill of Kankakee and George Hazen French of Carbondale came to Illinois to teach (but not necessarily botany) and several of our early botanists were self taught "naturalists". Among this last group are Harry Patterson of Oquawka, John Wolf of Canton, and the subject of this essay, Elihu Hall of Athens (Figure 1).

I first became interested in Elihu Hall while studying Hall's Bulrush (*Schoenoplectus hallii*) (Figure 2) in the early 1990s. The type locality for this sedge was Mason County, Illinois and it had been discovered in 1861 by local botanist Elihu Hall of Athens, IL. After reading brief biographies of him in Kibbe (1953) and Jones and Fuller (1955), I had a vision of him as a plant collector on the frontier braving the elements and the Indians of the West as he discovered and collected many plants that were new to science. I wanted to know more about this man.

Since I lived in Springfield at the time, and Hall's home town of Athens was just up the road, I drove up to look for signs of him. I visited the Hall Cemetery on the south edge of Athens where I found his grave. Then I noticed the name of his infant son who was also buried there. Linneus Hall had died at 11 weeks of age in 1872 and with the given name of Linneus, there seemed no doubt that his father was a botanist.

Someone had pointed out that Elihu's home still stood a short distance to the west of "Lincoln's Post Road" from Athens to Springfield, so I went in search of it. It was easy to spot just south of Athens because of the large white pine trees that formed a grove around it. Undoubtedly the pines were planted by Hall back in the 1860s. I stopped to take a photo of it and while there I met the owner who invited me in to see the interior of the home (Figure 3). This was back in 1994, and at that time the interior of the house looked a lot like I imagined it did in Hall's day. Later, in researching Elihu, I found out how he got the money to build this home, but more about that later.

Elihu Hall was born June 4, 1822 in Patrick County Virginia (Mulligan, 1884). Patrick County is bordered on the west by the crest of the Blue Ridge Mountains and on the south by the North Carolina boundary. This rich floristic area was his home until the age of 7 and may have influenced his interest in plants. His biographical sketch in Baskin (1879), the "History of Menard and Mason Counties Illinois", notes that his father Fleming and other family members moved to Menard County Illinois (then Sangamon County) in 1829. County records indicate his uncle Abner Hall and Harry Riggin were the founders of the town of Athens and recorded a survey of the town on September 7, 1831. Excepting the now extinct New Salem, Athens is the oldest town in the county.

Elihu had virtually no formal education, but learned to read, write, and the basics of land surveying on his own. As he grew up on the Illinois frontier he became interested in the plants and animals he saw and began sketching and coloring drawings of them. His special interest was the plants, and he soon began acquiring botany books and corresponding with others interested in plants. From these contacts he learned to press and dry specimens rather than draw them and thus began a lifetime interest in collecting, studying, and exchanging plants.

Like many people of his era Elihu became a farmer and with his knowledge of surveying, he also became Menard County Surveyor. These vocations helped support him while he pursued his interest in plants. In the winter of 1846 he suffered an almost fatal hemorrhage from his lungs caused from severe over-exertion. Thus at age 24 he appears to have contracted

[1] 3626 Riverpoint Lane, Metropolis, IL 62960.

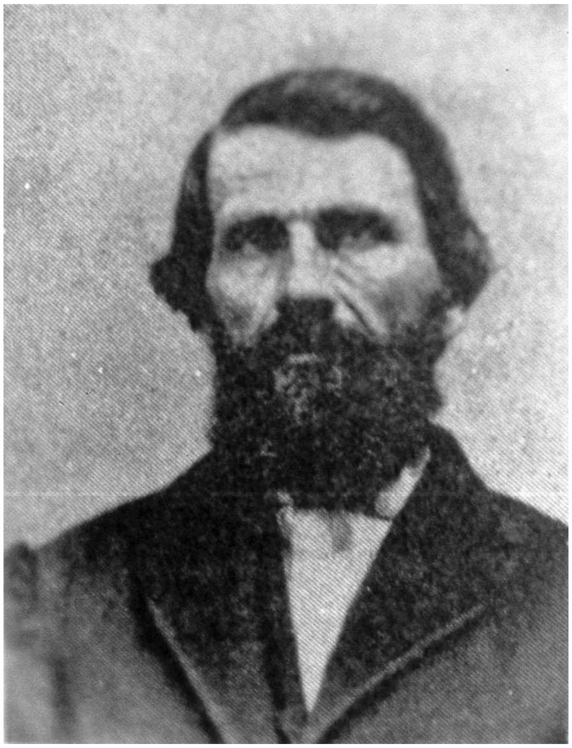

Figure 1. Elihu Hall in a photograph he distributed to botanists he corresponded with.

"consumption" as tuberculosis was known then. This disease weakened him for the remainder of his life, and eventually was the cause of his death on September 24, 1882.

In 1871, at the age of 49, he married Elizabeth Brown who was 21 years his junior. Their first child, Linneus was born in early May of 1872 but lived only 11 weeks. They had three additional children; Una, Julian, and Hubert. The latter was only five years old when his father died (Milligan, 1884). Because of his late marriage, Elihu was free of responsibility for supporting a family for much of his adult life. He apparently spent a lot of this time on his studies of and exploration for plants. In addition to exchanging dried plant specimens, he also acquired seeds and living plants and then established them in gardens. Milligan (1884) states that he had a planting of over 50 species of willow in a moist hollow near his home. By 1858 his prominence as a botanist was such that he was one of the original organizers of The Illinois Natural History Society at Bloomington. This Society and its collections changed names over the years, eventually becoming the Illinois Natural History Survey we know today.

Hall initially carried out correspondence and plant exchanges with many fellow botanists as a means to get identifications for plants that he could not put names on himself and to build up his private herbarium. Many specimens were sent for identification to the most prominent botanist of the day, Asa Gray of Harvard.

At some point, probably in the 1850s, Elihu realized that there was a market for plant specimens, especially from previously unexplored regions. His first expeditions were apparently to the nearby Great Plains of Kansas and Nebraska. Here he collected new species subsequently named for him such as Sand Bluestem (*Andropogon hallii*), and *Carex hallii.*

His approach to commercial collecting appears to have been to plan a trip and then solicit subscribers from the many botanists that he corresponded with. These eventually included Gray at Harvard, The Philadelphia Academy of Sciences, New York Botanical Garden, and the Smithsonian Institution. With enough "backers" subscribing, he planned and executed the expedition. In addition to plants, he also often collected mineral specimens and in the later years shells of fresh water snails and mussels, and land snails. Whether he discovered new minerals or mollusks I do not know, but apparently there was a market for these specimens.

Aside from his Central Illinois collections, he made collecting trips to Colorado, Oregon, Texas, Arkansas, and Michigan. He made shorter collecting forays into Missouri, Iowa, Kansas and Nebraska (Milligan, 1884). My initial vision of him traveling by horseback or stage on the frontier seems to be more romantic than accurate. It appears that he often traveled by rail and soon after rail transport reached an area, frequently, so would Hall.

His first major expedition was the 1862 trip to Colorado. Dr. Charles Parry, the first botanist of the U. S. Department of Agriculture, had made a trip to the Rockies of Colorado Territory in 1861. He had collected some plants while making a general survey of the land. His plant specimens were examined by Asa Gray who determined that several were new species. When Parry returned to Colorado in 1862, Elihu Hall and his cousin Jared Harbour accompanied him with materials to make a major collection of plants. I suspect that Harbour was along to help with the collecting and drying of specimens as I have not seen him mentioned elsewhere as a botanist.

It appears that Gray had probably recommended Hall to Parry as someone who could make a large collection of good plant specimens, one set of which was to go to Gray, possibly in exchange for his identifying and naming them (Gray 1863). While Parry made some plant collections of his own, they were kept separate from the Hall and Harbour collection, which they had the right to sell as their compensation for the trip. Hall and Harbour collected 10 sets of over 700 species which has been called the largest collection of

Figure 2. Hall's Bulrush from wet sandy land near Snicarte, Mason County, Illinois. The specimen is 9 inches (23 cm) tall.

plants ever made in Colorado in a single season (Schneider and Schneider 2010).

The collected plants included more than 30 species that were new to science, including the beautiful *Penstemon hallii* ((Figure 4) and *Penstemon harbouri*. Among the other new species were *Asclepias hallii, Juncus halli, Astragalus hallii,* and the interesting *Heuchera hallii*. Hall had a special interest in mosses and collected two new moss species as well, *Campylopus hallii* and *Orthotrichum hallii* (Meehan, 1884). I photographed Hall's Penstemon at timberline on Pike's Peak last summer. Apparently the goal of this trip and collection was to raise money for the house that Elihu was going to build near Athens. Since the house stands to this day, I suspect that the objective was met.

Hall's two other major expeditions were to Oregon in 1871 and Texas in 1872. The Railroad had reached eastern Oregon by 1870 and it was still largely unknown botanically so a collection from there was sure to be in demand. Judging from the locations of many species named for him, he collected across the state. *Lomatium hallii* came from the desert eastern part of the state, while *Aster hallii, Agrostis hallii,* and the peculiar *Scoliopus hallii* came from the coastal ranges. The latter is related to Trilliums with the common name of Oregon Fetid Adder's Tongue. It is currently available in the wildflower trade. He even collected *Lobaria hallii*, a foliose lichen new to science, on this trip. Gray (1872) published a description of this collection and Hall (1877) published his observations on the woody plants of Oregon based on this trip.

His 1872 trip to Texas was partly for collecting and partly for his health. He thought the climate of Texas would help his "consumption" (Kibbe, 1953) and there was a demand for plant specimens from that region. His collection was from East Texas, which is as humid

Figure 3. The home built by Elihu Hall south of Athens, Illinois.

as Illinois, but the trip may have helped his illness some. This collection included 800 species and was probably the source for new species like *Panicum hallii*. This collection was described by Asa Gray (1873). In a letter to Harry Patterson in 1879 (Kibbe, 1953) Hall offered to sell Patterson a set of the Texas collection for $50.00. He indicated that this was less than half of the regular price, and that he only had 3 sets of the collection left. This is the only place I found a price quoted for one of his collections.

Figure 4. Hall's Penstemon at timberline on Pike's Peak Colorado.

There is some interesting information in the letters Hall wrote to Harry Patterson in the 1870s. These were all published by Kibbe (1953) along with all of Patterson's correspondence with botanists. They give the reader insight into Elihu's personality and nature. Hall also mentions some information on the local flora around Athens.

For example, in a letter of July 7, 1877, he writes "*Cypripedium candidum* I do not find here any more. It was always rare and has entirely disappeared". In the same letter relative to *Cypripedium* he writes "our only representatives of the family are pubescens and spectabile; the former rather common in rich shady woods and the latter only on steep moist hills on the Sangamon River". Spectabile is what we now call *C. reginae* for which there are no records from Menard County to my knowledge. It is worth noting that Floyd Catchpole discovered *C. candidum* in both Cass and Mason Counties, adjacent to Menard County, in recent years.

Toward the end of his life, Hall abandoned plant collecting. This was probably because his failing health and physical inability to continue the expeditions, and also the need to support a family. He is quoted in Kibbe (1953) as saying he "could make more money raising taters than I can drying plants".

His personal herbarium contained about 15,000 specimens at his death, almost certainly the largest private herbarium in the state at the time. Most of this collection ended up in the University of Illinois

Herbarium, now at the Illinois Natural History Survey. I believe some of his freshwater mussel shells survive in the Illinois Natural History Survey collection as well. I have been unable to locate a list of all species new to science collected by him and those named for him, but the number must be considerable.

I am sure much more can be learned about Elihu if one takes the time. The more I searched on line, the more I found until I just quit looking. He was a remarkable person for having accomplished so much after educating himself and being weakened by disease. Some of the plants he discovered are available in the trade for our gardens and natural community restorations. These include *Andropogon hallii, Panicum hallii, Pensteomon hallii, Astragalus hallii,* and *Scoliopus hallii*. If we grow any of these, we should take time to remember the botanist who first discovered them.

Literature Cited

Baskin, O. L. 1879. History of Menard and Mason Counties, Illinois. Chicago: O. L. Baskin and Co. 848.

Gray, A. 1863. Enumeration of the species of plants collected by Dr. C. C. Parry, and Messrs. Elihu Hall and J. P. Harbour, during the summer and autumn of 1862, on and near the Rocky Mountains of Colorado Territory, lat 39–41. Pages 55–80 *in* the Proceedings of Academy of Natural Sciences of Philadelphia.

Gray, A. 1872. Enumeration of a collection of plants made by Mr. Elihu Hall in Oregon in summer of 1871. Pages 372–412 *in* Proceedings of the American Academy of Arts and Sciences.

Gray, A. 1873. Plantae Texanus, a list of the plants collected in eastern Texas in 1872 and distributed to subscribers by Elihu Hall. Salem, Illinois.

Hall, E. 1877. Notes on the arboreus, arboresecent, and suffruticose flora of Oregon. Botanical Gazette. Volume ii. Pages 85–95.

Jones, J. N. and G. D. Fuller. 1955. Vascular plants of Illinois. Illinois State Museum Scientific Series. Volume VI. Urbana: University of Illinois Press.

Kibbe, A. 1953. Afield with plant lovers and collectors; botanical correspondence of the late Harry N. Patterson with the great botanical collectors and distributors of America from 1870 to 1919. Carthage, Illinois. Pages 301–319.

Meehan, T. 1884. Obituary of Elihu Hall. The Gardner's Monthly and Horticulturist 24:350.

Milligan, J. M. 1884. Obituary of Elihu Hall. Botanical Gazette 9(4):59–62.

Schneider, A. and B. Schneider. 2010. Southwest Colorado wildflowers, ferns, & trees. http://www.swcoloradowildflowers.com/biographies/

Erigenia, Number 25, Spring 2012, pp 8–13

Effects of Hot Water on Breaking Seed Dormancy of the Endangered Kankakee Mallow, *Iliamna remota* Greene (Malvaceae)

April McDonnell[1], Marissa Grant[1], and Janice Coons[1,2]

Abstract: *Iliamna remota* Greene (Kankakee mallow, Malvaceae) is listed as endangered in Illinois and is endemic to Langham Island in the Kankakee River, Kankakee County, Illinois. Information on ways to break seed dormancy of *I. remota* would be useful for restoration and management. The purpose of this study was to determine if hot water at different temperatures and for different lengths of time would break seed dormancy. Seeds were dipped for 60 seconds into water at 70, 80, 90 or 100°C with 22°C dips as a control. In another trial, seeds were dipped into 80°C for 0, 10, 20, 30 or 60 seconds. Each treatment included six replications with 25 seeds each. Seeds were germinated in Petri dishes in a seed germinator at 25°C with continuous light. Germinated and fungal contaminated seeds were counted for three weeks. When comparing temperatures with dips for 60 seconds, germination percentages were significantly greatest with dips at 80°C (63%), lower at 70°C (46%), still lower at 90°C (29%), and lowest at 100°C (15%) or control (9%). When comparing times with dips at 80°C, 20 seconds was the best time. Hot water dips for 60 seconds at all temperatures significantly decreased contamination (< 5%) relative to the control (15%). Thus, hot water dips at 80°C provided the best hot water dip for breaking seed dormancy of *I. remota* when using seeds to grow plants for restoration. In addition, our findings suggest that high soil temperatures created during burns for management could enhance seed germination in soils.

Introduction

Iliamna remota Greene (Kankakee mallow, Malvaceae) is a state endangered species in Illinois, endemic to Langham Island in the Kankakee River, Kankakee County, Illinois (Herkert and Ebinger 2002, Illinois Endangered Species Protection Board 2005, Schwegman 1991, USDA-NRCS 2007). The species was first discovered on the island by Reverend E. J. Hill in 1872 (Sherff 1946, Strausbaugh and Core 1932). In 1966, Langham Island was dedicated as an Illinois Nature Preserve with the sole purpose of preserving the only known native population of *I. remota* (McFall and Karnes 1995). Populations also occur in Indiana and Virginia where it is presumed to be introduced by efforts of the Wild Flower Preservation Society of Chicago in the 1920s when seeds were spread along railroads (Glass *et al*. 2003, Jacobs 1992, Keener 1964, Sherff 1949, Swinehart and Jacobs 1998). *Iliamna corei* (Sherff) Sherff recently was reported as a synonym of *I. remota* based upon DNA analysis (Bodo Slotta and Porter 2006), although an earlier study with DNA analysis concluded that *I. corei* was a subspecies of *I. remota* (Stewart *et al*. 1996). *Iliamna corei* (*I. remota*) occurs in only one location in Virginia (Baskin and Baskin 1997). Another related species, *I. longisepala* (Torr.) Wiggins, is a rare endemic forb known from three counties in Washington (USDA-NRCS 2007).

In Illinois, *I. remota* plants are found on slopes with rocky, gravelly or sandy soils that are well drained (Glass *et al*. 2003, Schwegman 1984). Plants of *I. remota* are shade intolerant requiring full sun, and hence perform best in open, sunny areas (Baskin and Baskin 1997, Glass *et al*. 2003, Keener 1964, Schwegman 1984). Management to maintain *I. remota* on Langham Island began in 1983 to keep these areas shade-free involving removal of invasive shrubs (especially *Lonicera maackii* (Rupr.) Maxim. and *Rosa multiflora* Thunb.) via herbicide and burning (Glass *et al*. 2003, Schwegman 1991).

Iliamna remota reproduces both from vegetative structures and from seeds. Plants can spread vegetatively

[1] Department of Biological Sciences, 600 Lincoln Avenue, Eastern Illinois University, Charleston, Illinois 61920.
[2] jcoons@eiu.edu

from thick, vigorous rootstocks, although this reproduction varies with habitat (Wadmond 1932). Root crowns develop in September for the next year's growth, and these buds usually are not harmed by freezing or by fire (Schwegman 1984). New plants also are reported to propagate easily from seeds when being used to cultivate plants for use in state parks, roadsides or private lands (Flood *et al.* 2000). On Langham Island, plants flower in July to August with pink-purple flowers that are most likely pollinated by insects, and small but heavy seeds are shaken from capsules in the end of September (Glass *et al.* 2003, Schwegman 1984). Seeds of *Iliamna remota* remain in the seed bank for at least 10 years (Glass *et al.* 2003), and remained viable for at least 4 years (Swinehart and Jacobs 1998). Schwegman (1984) reported that older seeds (2+ years old) germinated more readily than fresh seed. Although seeds are present, seedlings often are only found following an apparent stimulation by fire on Langham Island (Glass *et al.* 2003), which may be due to breaking of seed dormancy.

Iliamna remota seeds are dormant and may require treatment to break dormancy. Without seed pretreatment, only a few (≤10%) *I. remota* seeds germinated (McDonnell, pers. obs.). However, when seeds were exposed to cold moist stratification (Flood *et al.* 2000), scarification (Swinehart and Jacobs 1998, Wadmond 1932), and hot water (Wadmond 1932, Hilscher and Preece 1994, McDonnell *et al.* 2006), higher seed germination than controls resulted. Unfortunately replicated trials were not included in these reports with warm or hot water. Dry heat scarification resulted in > 80% germination when seeds were treated at 80°C for 30 or 60 minutes. *Iliamna corei (I. remota)* seeds subjected to 1 to 13 soaks in sulfuric acid for 1-hour periods followed by rinses with tap water resulted in as high as 90% germination. *Iliamna corei (I. remota)* seeds dipped in boiling water for 1, 3, 5, 10, and 20 seconds germinated as high as 93%, whereas germination declined for seeds dipped in boiling water longer than 20 seconds. Seeds dipped in boiling water for 50 seconds or longer were mostly killed (Baskin and Baskin 1997).

Burning also may aid the ability of *I. remota* to reproduce from seeds as dense stands of seedlings were found during July in areas where brush piles that were burned in April had created hot spots at Langham Island (Schwegman 1984). For *Iliamna corei (I. remota)* in greenhouse studies, seeds on the surface of soil in flats germinated when subjected to fire, breaking dormancy induced by a durable (hard) seed coat (Baskin and Baskin 1997). For *Iliamna longisepala*, fire also broke seed dormancy and more germination occurred when burn severity was higher rather than lower, and more occurred with fall burns than spring burns, when none were found (Harrod and Halpern 2005). Given the effects that fire has on increasing seedling numbers at Langham Island and seed germination in related species, further work is needed to determine how high temperatures could affect seed dormancy of *I. remota*.

Seeds of *I. remota* germinate poorly without treatments to break dormancy, and fire is reported to stimulate germination of these seeds. For related species, high temperatures including hot water dips effectively broke dormancy. The objective of this study was to determine how water dips at temperatures of 22 (control), 70, 80, 90 or 100°C, and for times of 0 (control), 10, 20, 30 or 60 seconds at 80°C affect seed germination of *I. remota*. This information should be useful for propagating plants in controlled environments for conservation and restoration efforts.

MATERIALS AND METHODS

Iliamna remota seeds were obtained from Prairie Moon Nursery (Winona, MN) in April of 2005. Seeds were purchased commercially rather than collected from natural populations such as Langham Island to eliminate possible negative impacts of seed removal from natural areas. Seeds were stored in a seed desiccator at 4°C and ≤ 40% relative humidity until used for this study in January 2006.

Temperature treatments

Seeds were dipped in 22 (room temperature control), 70, 80, 90 or 100°C water for 60 seconds. Twenty-five seeds were placed in each of six plastic Petri dishes (100 × 15 mm) for each temperature treatment. Petri dishes contained 3 sheets of Whatman #1 (Fisherbrand®, Pittsburg, PA) filter paper (90 mm) with 6 ml of distilled water. Seeds were dusted with a fungicide, thiram powder (50% active ingredient, tetramethylthiuram disulfide). Petri dishes were sealed with Parafilm® "M" Laboratory Film (Pechiney Plastic Packaging, Chicago, IL) to prevent moisture loss. Dishes were placed randomly in a plastic Rubbermaid® tub (33 cm × 24 cm × 10 cm) in a Percival Scientific® (Perry, IA) seed germinator with a mean (± SE) temperature of 25 ± 0°C and continuous light (17 ± 1 μmol/m^2/sec). Light was recorded in nine random areas inside the seed germinator with an Apogee® (Logan, UT) quantum sensor. Numbers of germinated (as measured by radicle emergence) and fungal contaminated seeds were recorded daily for 20 days when germination percentages had reached a plateau. Contamination counts help assess what percentage of seeds may have not germinated due to fungal contamination as opposed to other factors.

Time treatments

Seeds were dipped in 80°C water for 0, 10, 20, 30 or 60 seconds. The same germination protocol was

Table 1: Mean (± SE) percentage of seeds germinated or contaminated after 20 days following water dips for 60 seconds at different temperatures. ANOVA results reported. Different lower case letters denote significant differences within a column (Duncan's multiple range test).

Temperature (°C)	Germination (%) $F = 27.49; P < 0.001$	Contamination (%) $F = 10.55; P < 0.001$
22 (control)	9.3 ± 2.0 d	14.7 ± 3.4 a
70	46.0 ± 4.0 b	4.7 ± 2.4 b
80	63.3 ± 4.3 a	0.7 ± 0.7 b
90	29.3 ± 7.0 c	0.0 ± 0.0 b
100	14.7 ± 2.0 d	0.7 ± 0.7 b

utilized for testing time as for temperature. Numbers of germinated and contaminated seeds were recorded weekly for three weeks when germination percentages had reached a plateau.

Statistical analyses

Means and standard errors were calculated for the number of germinated and contaminated seeds. All data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's multiple range test at 5% level to determine significance. Data were analyzed with SPSS 15.0 for Windows (2006) and Microsoft® Office Excel version 12 (2007).

RESULTS

Temperature treatments

A significantly greater percentage of seeds germinated after 20 days when dipped in water at 80°C (63.3%) followed by 70°C (46.0%), and then 90°C (29.3%) (Table 1). The lowest percentage of seeds germinated when dipped in a control treatment (22°C) or 100°C water, which did not significantly differ from each other. Seeds dipped in 70°C or 80°C water also germinated at a more rapid rate compared to other temperatures (Figure 1). Dipping the seeds in hot water treatments also decreased the number of fungal contaminants as the control (14.7%) had significantly more contamination compared to other treatments (Table 1).

Time treatments

Seeds dipped in 80°C water for 20 seconds resulted in significantly higher percent germination (54.7%) compared to all other soaking times (Table 2). Although percent germination was not significantly different among seeds exposed to 10, 30 or 60 seconds, seeds that were not subjected to hot water (control) resulted in significantly lower percent germination (Table 2). Germination rates were slightly higher with dips for 20 seconds relative to other times, and much lower for the control relative to all other times (Figure 2). Contamination was not significantly different between treatments for different times (Table 2).

DISCUSSION

Germination varied following dips of seeds into water of different temperatures. The 70°C water dip had a lower number of seeds germinated than the 80°C water dip, but still a greater number of seeds germinated compared to other temperatures. The optimal temperature (80°C) in this study closely parallels the temperature (82°C) used by Hilscher and Preece (1994), although germination percentages or tests of other temperatures and times were not reported in

Table 2: Mean (± SE) percentage of seeds germinated or contaminated after three weeks following water dips at 80°C for different times. ANOVA results reported. Different lower case letters denote significant differences within a column (Duncan's multiple range test).

Time (seconds)	Germination (%) $F = 14.88; P < 0.001$	Contamination (%) $F = 0.72; P = 0.585$
0 (control)	9.3 ± 1.7 c	8.7 ± 3.3 a
10	38.7 ± 6.2 b	10.0 ± 4.8 a
20	54.7 ± 3.5 a	7.3 ± 2.6 a
30	40.7 ± 4.4 b	5.3 ± 3.0 a
60	33.3 ± 4.3 b	2.7 ± 2.7 a

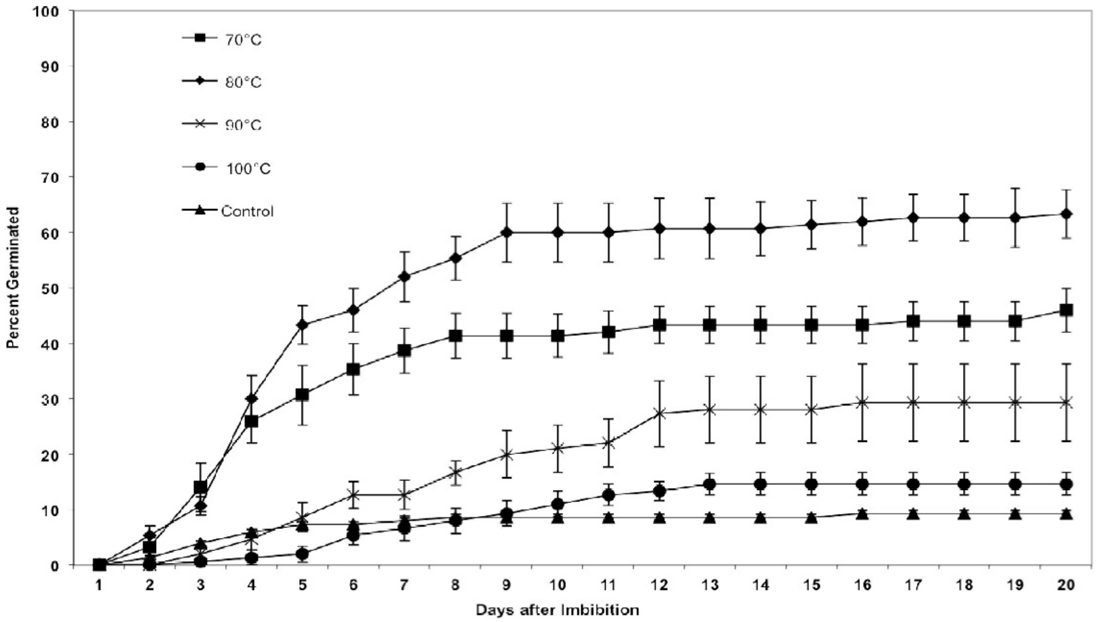

Figure 1. Mean percentages (± standard errors) of seeds germinated per day following water dips for 60 seconds at different temperatures.

their study. Seeds dipped in both 70 and 80°C water germinated earlier than seeds exposed to all other temperatures, indicating effective temperatures for breaking dormancy. Temperatures above 80°C may have been too hot, thus injuring or killing embryos in seeds, and resulting in lower germination percentages. Hence hot water dips at different temperatures affected germination.

When different times were tested at 80°C, seed germination was significantly higher after a 20 second exposure (54.7%) compared to other times. The length of time per water dip also affected the percentage of *I. corei (I. remota)* seeds germinated, when the number of *I. corei* (*I. remota)* seeds germinating declined after being dipped for longer than 20 seconds in boiling water (Baskin and Baskin 1997). In our study, the percentage of germinated *I. remota* seeds declined after being dipped for longer or less than 20 seconds in 80°C water. Also, control seeds (those not dipped in hot water) resulted in significantly lower percent germination (9.3%) compared to seeds soaked in hot water. Control seeds of *I. corei (I. remota),* displayed even lower (1%) germination compared to the percentage (9.3%) of *I. remota* seeds that were dipped in room temperature water in our study (Baskin and Baskin 1997). These studies show that not treating seeds with hot water significantly decreases germination for *Iliamna remota*.

An inconsistent finding occurred after subjecting seeds to dips in 80°C water. In the initial temperature trial experiment (60 seconds), percent germination was 63.3%, but in the time trial experiment (60 seconds), percent germination was considerably lower (33.3%) when dishes were checked only once a week resulting in less frequent water additions. For temperature trials, dishes were checked daily, and additional water was added as needed. However, for time trials, dishes were checked only once a week, so water additions were less frequent. These differences in frequency of water additions may have affected germination in temperature vs. time trials.

Temperature and soaking time played a role on the incidence of seed-borne contaminants. The greatest percentage of contamination (14.7%) was in the treatment where seeds were dipped in room temperature (22°C) water for 60 seconds, as hot water treatments had significantly lower contamination compared to the room temperature control. Thus, dipping seeds in hot water effectively reduced contaminants compared to dipping seeds in room temperature water. The percentage of contamination was not significantly different between time treatments.

A significantly higher percentage of seeds germinated when dipped in water at 70 to 90°C compared to those exposed at ambient temperature or 100°C. Thus, hot water treatments were effective in breaking dormancy of *I. remota* seeds. Some species within Malvaceae are known to possess durable (hard) seed coats prone to weakening by hot water exposure

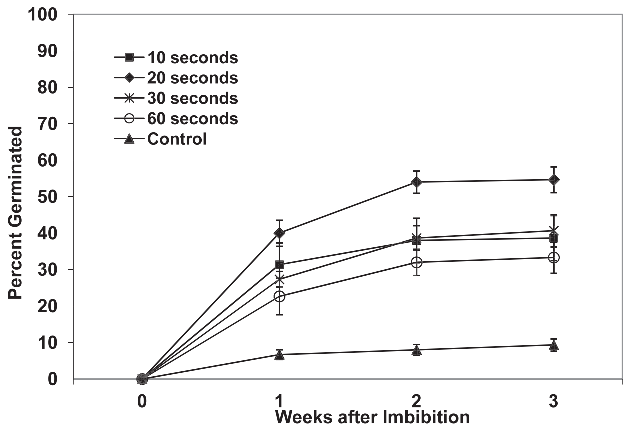

Figure 2. Mean percentages (± standard errors) of seeds germinated per week following water dips at 80°C for different times.

(Baskin and Baskin 1997). In this study, hot water effectively broke dormancy of *I. remota* seeds suggesting that physical seed dormancy in this species is attributed to a durable (hard) seed coat. Studies that test water imbibition following mechanical scarification would lend further support for this hypothesis. If true, overcoming seed coat-related dormancy *in situ* would have implications for the conservation of this species. For example, seed dormancy could conceivably be removed by higher temperatures triggered by fires, by freezing and thawing cycles, by wetting and drying, or a combination of these factors.

The information presented in this study should be useful for restoration and management of this rare species. For restoration purposes, *I. remota* may be grown in controlled environments where seed germination will be enhanced with hot water dips as reported in this study. For management of the *I. remota* population on Langham Island, previous studies showed that controlled burns dramatically increased seedling development (Glass *et al.* 2003). This increase following burns could relate to breaking seed dormancy from high temperatures (70–90°C) as temperatures found to increase germination are within the range of soil temperatures reported during fires in other habitats such as 50–225°C (Davis *et al.* 1989), 65–115°C (Auld 1986), and 70–125°C (Shea *et al.* 1979). Baskin and Baskin (1997) found that fire was a natural treatment for *I. corei (I. remota)* to break seed dormancy. Hence, controlled burns near populations of *I. remota* could help to break seed dormancy, in addition to control for woody invasive species. Thus, hot water may be useful for production of plants for use in restoration.

ACKNOWLEDGMENTS

Thanks to Brian Craven, Jason Cummings, Angela King and Sarah Westfall (students at Eastern Illinois University) for assistance with data collection. Thanks to John Ebinger for comments on the manuscript.

LITERATURE CITED

Auld, T. D. 1986. Population dynamics of the shrub *Acacia suaveolens* (Sm.) Willd.: Fire and the transition to seedlings. Australian Journal of Ecology 11:373–385.

Baskin, J. M. and C. C. Baskin. 1997. Methods of breaking seed dormancy in the endangered species *Iliamna corei* (Sherff) Sherff (Malvaceae), with special attention to heating. Natural Areas Journal 17:313–323.

Bodo Slotta, T. A. and D. M. Porter. 2006. Genetic variation within and between *Iliamna corei* and *I. remota* (Malvaceae): Implications for species delimitation. Botanical Journal of the Linnean Society 151:345–354.

Davis, F. W., M. I. Borchert, and D. C. Odion. 1989. Establishment of microscale vegetation pattern in maritime chaparral after fire. Vegetatio 84:53–67.

Flood, R. M., D. Horvath, and G. Blessman. 2000. Protocol for growing Kankakee mallow (*Iliamna remota*). Native Plants Journal 1:13–14.

Glass, W., J. E. Schwegman, R. R. Heidorn, and W. E. McClain. 2003. Twenty Years of the Endangered Kankakee Mallow (*Iliamna remota*, Greene, Malvaceae) on Langham Island, Kankakee County, Illinois. Illinois Department of Natural Resources Report. Springfield, Illinois. 5 pp.

Harrod, R. J. and C. B. Halpern. 2005. The seed ecology of *Iliamna longisepala* (Torr.) Wiggins, an East Cascade endemic. Natural Areas Journal 25:246–256.

Herkert, J. R. and J. E. Ebinger. 2002. Endangered and Threatened Species of Illinois: Status and Distribution, Volume I-Plants. Illinois Endangered Species Protection Board. Springfield, Illinois. 163 pp.

Hilscher, S. L. and J. E. Preece. 1994. Micropropagation of *Iliamna remota*, Kankakee mallow. HortScience 29:562. Abstract.

Illinois Endangered Species Protection Board. 2005. Checklist of Endangered and Threatened Animals and Plants of Illinois. Illinois Endangered Species Protection Board, Springfield, Illinois. 16 pp.

Jacobs, M. E. 1992. Preservation of a Historic Portion of the Wabash Railroad Site and Habitat of the Rare and Endangered Kankakee Mallow (*Iliamna remota*) Including Site of Its Discovery in Indiana. Preservation Proposal, Unpublished Report. Goshen College, Indiana. 4 pp.

Keener, C. S. 1964. New Virginia locality for *lliamna*. Castanea 29:191–192.

McDonnell, A. L., H. R. Owen, S. C. Jones, V. P. Gutowski, and J. E. Ebinger. 2006. Survey of the Illinois endangered Kankakee mallow, *Iliamna remota* (Greene), in Kankakee County. Erigenia 21:32–39.

McFall, D. and J. Karnes. 1995. A Directory of Illinois Nature Preserves, Volume 1. Northeastern Illinois. Illinois Department of Natural Resources, Springfield, Illinois. iv+195 pp.

Schwegman, J. E. 1984. State of Illinois Recovery Plan for *Iliamna remota* Greene. Division of Forest Resources and Natural Heritage. Illinois Department of Conservation. Springfield, Illinois. 18 pp.

Schwegman, J. E. 1991. The vascular flora of Langham Island, Kankakee County, Illinois. Erigenia 11:1–8.

Shea, S. R., J. McCormick, and C. C. Portlock. 1979. The effect of fires on regeneration of leguminous species in the northern Jarrah (*Eucalyptus marginata* Sm) forest of Western Australia. Australian Journal of Ecology 4:195–205.

Sherff, E. E. 1946. Notes on certain plants in the Gray's Manual range. Rhodora 48:89–98.

Sherff, E. E. 1949. Miscellaneous notes on dicotyledonous plants. American Journal of Botany 36:499–511.

Strausbaugh, P. D. and E. L. Core. 1932. *Phymosia remota*. Rhodora 34:142–146.

Stewart, N. C., Jr., G. Rosson, B. W. Shirley, and D. M. Porter. 1996. Population genetic variation in rare and endangered *Iliamna* (Malvaceae) in Virginia. Biological Journal of the Linnean Society 58:357–369.

Swinehart, A. L. and M. E. Jacobs. 1998. Rediscovery, status, and preservation of the endangered Kankakee globe mallow (*Iliamna remota*) in Indiana. Rhodora 100:82–87.

United States Department of Agriculture, Natural Resources Conservation Service. 2007. The PLANTS Database, Version 3.5 (http://plants.usda.gov) National Plants Data Center, Baton Rouge, Louisianna, Date accessed: February 2010.

Wadmond, S. C. 1932. *Phymosia remota* in captivity. Rhodora 34:207–209.

Erigenia, Number 25, Spring 2012, pp 14–22

Changes in Vegetation Abundance Following *Carya* (Hickory) Thinning and Prescribed Burning at Beadles Barrens Nature Preserve, Edwards County, Illinois

Bob Edgin[1], Roger Beadles[2], John E. Ebinger[3], and Michael Blackowicz[4]

Abstract: Groundlayer response to prescribed burning and gradual, bottom-up thinning of subcanopy trees in a degraded woodland was examined at Beadles Barrens Nature Preserve, southeast Illinois, in September 2004 and September 2010. Four prescribed burns were conducted during the study period. Prior to management, overall tree density averaged 294.5 trees/ha. *Quercus stellata* averaged 80.0 tress/ ha and *Carya* spp. averaged 169.3 trees/ha. Herbaceous species were sparse, oak regeneration was nearly non-existent, and a thick layer of leaf litter covered the forest floor. After the first burn, *Carex* spp. (sedges) had the highest importance value in the groundlayer followed by *Helianthus divaricatus*, *Acalypha virginica*, *Ageratina altissima* and *Acalypha gracilens*. Following thinning and burning, overall tree density was 185.2 trees/ha and *Carya* spp. density averaged 77.2 trees/ha. Groundlayer species with the highest importance values included *Helianthus divaricatus*, *Carex* spp., *Solidago ulmifolia*, *Carya* spp., and *Ageratina altissima*. The collective importance value for non-native species dropped from 6.5 in 2004 to 1.1 in 2010. The results of this study indicate that gradual bottom-up thinning combined with prescribed burning can be an effective and efficient method for increasing the abundance and diversity of desirable herbaceous species in a degraded open woodland community while minimizing risk of invasion by non-native species.

Introduction

Open woodlands and savannas were once common in forest-prairie interfaces throughout the midwestern United States (Nuzzo 1986). The understory vegetation in these communities was likely influenced by a number of factors including topography, soils, aspect, fire frequency and fire intensity (Anderson et al. 1999). Sites with grasses and forbs as the dominant understory vegetation probably experienced more frequent or less intense fires than those with a shrub-dominated understory (Nuzzo 1986).

Following European settlement, clearing, grazing, harvesting of timber for lumber and fuel and fire suppression severely altered or eliminated many of these communities. The structure of the remaining examples has been further altered by landscape fragmentation, invasion by non-native species and succession (Peterson and Reich 2001). These structural changes include increased tree density, canopy cover, and basal area; a shift to more shade tolerant and fire sensitive species; and often, a corresponding decrease in herbaceous species diversity and richness.

In southeastern Illinois, General Land Office surveyors usually described these areas as thinly timbered oak and hickory forests with hazelnut (*Corylus americana* L.), oak shrubs, or grassy understories (Edgin 1996, Edgin and Ebinger 1997). Most forested tracts that remain in these former forest-prairie interfaces are now closed-canopy forests with oak canopies, hickory-dominated subcanopies and groundlayers that have a thick layer of leaf litter with very low shrub and herbaceous species abundance (Taft 2005, McClain et al. 2007, Edgin and Ebinger 2008). Since few high quality examples of this community type remain in southeastern Illinois, preservation of this community type will most likely be accomplished through restoration of degraded examples.

The restoration of savannas and barrens has been the focus of several studies (White 1986, Testor 1989,

[1] Illinois Nature Preserves Commission, One Natural Resources Way, Springfield, IL 62701; corresponding author.
[2] RR 1, Ellery, Illinois 62833.
[3] Illinois Natural History Survey, 1816 South Oak Street, Champaign, Illinois 61820.
[4] Eastern Illinois University, 600 Lincoln Ave, Charleston, IL 61920.

Huddle and Pallardy 1996, Peterson and Reich 2001, Nielsen et al. 2003). Many of these early studies were concerned only with manipulation of the tree structure through prescribed burning or thinning without much regard for the herbaceous component. More recent studies have concentrated on the effects of fire and mechanical thinning on the herbaceous component (Taft 2002, Hutchinson et al. 2005, Hutchinson 2006, Phillips et al. 2007, Elliott and Vose 2010). Although the herbaceous response in these studies varied depending upon the initial condition of the community, the general consensus was that intense fires or mechanical thinning that rapidly increases light intensity promotes the most rapid response of the herbaceous component. However, given the small size of most open woodland remnants and the highly fragmented landscape of southeast Illinois, the likelihood of a fire being of sufficient intensity to kill canopy trees is remote and rapid mechanical thinning of the canopy may not be desirable because of the threat of invasion by non-native species (Hobbs and Huennke 1992, Anderson et al. 1996, Griffis et al. 2001, Dodson 2004). In this study, we examine the response of the groundlayer (herbaceous species and woody species < 50 cm tall) to prescribed burning, coupled with a gradual bottom-up thinning, of a small woodlot.

STUDY AREA

Beadles Barrens is a 10.1 ha nature preserve located in western Edwards County, Illinois, USA (38°21′04″N, 88°07′36″W). The preserve is situated on gently rolling terrain along an historic forest-prairie interface on the east side of what was referred to as Birk's Prairie (Edgin et al. 2005). The preserve consists of a 6.8 ha west and a 3.3 ha east management unit that are separated by a township road. The west unit is a high quality, barrens community dominated by native grasses and forbs. The east unit consists of a 1.4 ha subunit that was planted to row crops for several decades before being planted to native grasses and forbs prior to dedication in 2010 and a 1.9 ha subunit dominated by trees with no history of prescribed burning, timber harvests or grazing by livestock between the 1950's and 2003. The study area was located in the 1.9 ha tree-dominated subunit.

Soil in the study area is Ava silt loam, a deep, moderately well-drained, sloping soil with a fragipan (Hohlubner and Fehrenbacher 1972). This soil developed over 50 to 125 cm of loess deposited over Illinoian glacial till. It is low in organic matter and natural fertility and root growth may be somewhat limited by the fragipan.

In the study area, *Quercus stellata* Wang. (post oak) was the dominant canopy tree and hickories dominated the subcanopy layers. Prior to thinning and burning, herbaceous species were sparse, oak regeneration was nearly non-existent and a thick layer of leaf litter covered the forest floor. Prescribed burning and gradual bottom-up thinning (elimination of trees from the smallest size classes first) of the subcanopy trees were implemented to reduce leaf litter and gradually increase light intensity on the groundlayer in an attempt to shift the community toward an open woodland community that presumably would be more reminiscent of the pre-European settlement condition while minimizing the likelihood of invasion by invasive species.

Forest stands of 18.7 ha and 13.4 ha adjoin, or are near, the northern and southeastern boundaries of the preserve. These are second or third growth forests with an oak/hickory canopy, hickory subcanopy, and shrub and groundlayers dominated by non-native honeysuckles, *Lonicera maackii* (Rupr.) Herder and *Lonicera japonica* Thunb.

MATERIALS AND METHODS

Treatments

Prescribed burning was conducted on March 24, 2003, March 18, 2005, March 6, 2009, and March 6, 2010 by a four-person burn crew and took 60 to 90 minutes for each burn. Fall burning was contemplated for each of these burns, but fuel and moisture conditions were not favorable for fall burning. Prior to the first burn, there had been no measurable precipitation for two days preceding the burn and 0.29'', 0.08'' and 0.06'' on March 19, 20 and 21, respectively in the ten days prior to the burn. There was no measurable precipitation in the ten days preceding burns 2, 3, and 4. Air temperature at the time of ignition for each burn was 16° C, 13° C, 18° C, and 4° C, respectively. Relative humidity at the time of ignition was 37%, 41%, 71%, and 61%, respectively. Winds were southerly for all burns with speeds of 8 km/h, 16 km/h, 25 km/h and 6 km/h, respectively. More than 90% of the study area burned during each burn.

Gradual thinning of the understory hickory, *Ulmus* spp. (elms) and *Celtis occidentalis* L. (hackberry) was initiated in the spring of 2004. Fifteen to 20 trees were removed annually from 2004 through 2008 beginning with trees 10–15 cm dbh (diameter breast height). Larger diameter trees were not removed until all smaller diameter trees had been eliminated. Twenty five trees ranging from 17.3 to 30.6 cm dbh and having an average diameter of 22.9 cm dbh were thinned in 2009. Smaller diameter trees were felled and the stumps treated with a 25% active ingredient solution of glyphosate herbicide to prevent re-sprouting. Slash was limbed and cut into sections to allow it to lay on the soil surface and improve aesthetics, but was not removed from the site. Thinning in March 2009 was accomplished by girdling. These trees were girdled with a chainsaw and left standing to reduce the amount of debris on the forest floor. Girdle cuts were treated with 25% active ingredient solution of glyphosate herbicide. Thinning operations took about one hour annually.

Sampling

Sampling of the overstory (trees ≥ 10.0 cm dbh) was conducted in July 2004 and September 2010 in a 100 m × 75 m (0.75 ha) study area. To facilitate precise location of the study area for future studies electric fence posts were driven into the ground at each corner and at 25 m intervals along the perimeter of the study area. For ease of sampling, the study area was divided into quadrats that were 25 m on each side. All living and dead-standing trees ≥10.0 cm dbh were identified and their diameters recorded. During the 2010 sample, it was also noted if dead-standing trees had been girdled. From these data, density (stems/ha), basal area (m^2/ha), relative density, relative basal area, and importance value (relative density + relative dominance = 200) were determined for living trees. Density (stems/ha) was determined for dead-standing trees. The species and number of large saplings ≥ 2.5 cm dbh but <10.0 cm dbh and small saplings >50 cm tall but <2.5 cm dbh were also recorded in each overstory quadrat in 2010.

The groundlayer was sampled in September 2004 and September 2010 using 1 m square quadrats located at one meter intervals on alternating sides of a 100 m transect line that traversed the center of the study area from north to south. To facilitate precise location of the transect line for future studies, electric fence posts were driven into the ground at each end of the transect line. Odd numbered quadrats were located on the east side of the line; even numbered quadrats on the west. A single digit random numbers table was used to determine the number of meters each quadrat was located from the transect line. Percent cover of each species rooted within the quadrat was determined using the Daubenmire cover class system (Daubenmire 1959) as modified by Bailey and Poulton (1968). The modified cover class scale is as follows: class 1 = 0–1%; class 2 = 1–5%; class 3 = 5–25%; class 4 = 25–50%; class 5 = 50–75%; class 6 = 75–95%; class 7 = 95–100%. From these data, frequency (%), mean cover (%), relative frequency, relative cover, and Importance Value (relative frequency + relative cover = 200) were determined. Species richness (S), mean species density/quadrat, mean cover/quadrat (%), mean Coefficient of Conservatism, Floristic Quality Index (FQI), evenness (J) and species diversity (H′) were also determined. The mean Coefficient of Conservatism and FQI were determined by procedures outlined in Taft et al. (1997). Evenness and diversity were calculated using the Shannon-Wiener index (1949) as presented in Magurran (1988). Two-tailed t-tests were conducted to determine if changes in mean CC, species richness/quadrat and mean cover/quadrat were significant. Botanical nomenclature follows Mohlenbrock (2002).

RESULTS

During the 2004 overstory survey, 13 tree species were encountered, tree density averaged 294.5 trees/ha and basal area averaged of 20.0 m^2/ha (Table 1). *Quercus stellata* Wangh. (post oak) dominated the canopy with 80.0 stems/ha, and accounted for 27.2% of all trees and 47.4% of the total basal area/ha due to its abundance in the larger diameter classes. *Carya ovata* (Mill.) K. Koch (shagbark hickory) was the dominant subcanopy species with 124.0 trees/ha and accounted for 29.2% of the basal area with most individuals less than 30 cm dbh. Other tree species were uncommon, only *C glabra* (Mill.) Sweet (pignut hickory) and *C. tomentosa* (Poir) Nutt. (mockernut hickory) exceeded 20 stems/ha. Four dead-standing, non-girdled trees having diameters of 11.5, 22.2, 24.2 and 44.5 cm were recorded

In 2010, following thinning and prescribed burning, overall tree density was reduced by 37.1% to 185.2 trees/ha and basal area was reduced to 16.4 m^2/ha (Table 1). Density of oaks increased slightly because of recruitment of saplings into the tree category. *Carya ovata* density, in contrast, was reduced by 54.9% to 55.9 trees/ha due to aggressive thinning. *Carya glabra* density remained relatively constant whereas *C. tomentosa* had been eliminated from the stand. Twenty five dead-standing trees that had been girdled in 2009 with an average diameter of 22.9 cm were recorded. Among the large saplings, *Quercus alba* density averaged 10.6 stems/ha and *Q. velutina* averaged 5.3 stems/ha. No other large or small saplings were recorded.

A total of 68 species was recorded in the 2004 groundlayer survey (Table 2). Collectively, the sedges (*Carex blanda* Dewey, *C. cephalophora* Muhl., *C. hirsutella* Mack, and *C. pensylvanica* Lam.) had the highest importance value (I.V. of 28.8), followed by *Helianthus divaricatus* L. (woodland sunflower), *Acalypha virginica* L. (slender-seeded mercury), *Ageratina altissima* (L.) R. M. King & H. Robins. (white snakeroot) and *Oxalis fontana* Bunge. (yellow wood sorrel) (Table 2). Seven additional species or taxonomic groups had IV's > 5.0. Mean species richness/quadrat was 7.4, while mean cover/quadrat was 54.35%. The mean CC and FQI were 2.3 and 19.8, respectively. Diversity was 3.51 and evenness was 0.83.

Overall, the abundance of many ground layer species changed dramatically in the six year between

Table 1: Densities (stems/ha) by diameter classes (cm), total density (stems/ha), basal area (m^2/ha) for living tree species at Beadles Barrens Nature Preserve, Edwards County, Illinois during sampling in 2004 and 2010.

	Density (Trees/ha) by diameter class (cm)												Basal Area (m^2/ha)	
	10.0–19.9		20.0–29.9		30.0–39.9		40.0–49.9		50.0–59.9		Total trees/ ha			
Species	2004	2010	2004	2010	2004	2010	2004	2010	2004	2010	2004	2010	2004	2010
Quercus stellata	6.7	6.7	20.0	18.7	21.3	22.6	16.0	12.0	16.0	22.7	80.0	82.7	9.477	10.555
Carya ovata	33.3	1.3	66.8	25.3	22.7	28.0	1.3	1.3	—	—	124.1	55.9	5.841	3.081
Carya glabra	8.0	—	10.7	5.3	2.7	10.7	1.3	5.3	—	—	22.7	21.3	1.015	1.479
Quercus velutina	2.7	2.7	1.3	4.0	1.3	1.3	1.3	1.3	1.3	1.3	7.9	10.6	0.803	0.764
Quercus alba	2.7	2.7	—	2.7	2.7	1.3	—	—	—	—	5.4	6.7	0.285	0.202
Quercus imbricaria	6.7	2.7	1.3	2.7	1.3	—	—	—	—	—	9.3	5.4	0.308	0.222
Fraxinus lanceolata	—	—	—	—	1.3	1.3	—	—	—	—	1.3	1.3	0.083	0.089
Juglans nigra	—	1.3	—	—	—	—	—	—	—	—	—	1.3	—	0.010
Carya tomentosa	5.3	—	9.3	—	6.7	—	1.3	—	—	—	22.6	—	1.433	—
Morus rubra	5.3	—	1.3	—	—	—	—	—	—	—	6.6	—	0.159	—
Prunus serotina	1.3	—	—	—	1.3	—	1.3	—	—	—	3.9	—	0.341	—
Celtis occidentalis	1.3	—	2.7	—	—	—	—	—	—	—	4.0	—	0.155	—
Ulmus alata	4.0	—	—	—	—	—	—	—	—	—	4.0	—	0.051	—
Ulmus americana	2.7	—	—	—	—	—	—	—	—	—	2.7	—	0.047	—
Totals	80.0	17.4	113.4	58.7	61.3	65.2	22.5	19.9	17.3	24.0	294.5	185.2	19.998	16.402

Species	2004 Dead-standing trees Diameters (cm)	2010 Dead-standing trees (excluding girdled trees) Diameters (cm)
Quercus stellata	14.1, 21.1, 35.5, 46.2	22.2, 44.5
Quercus imbricaria		11.5, 24.1
Carya ovata	15.5, 16.7	
Morus rubra	14.2, 23.1	
Ulmus spp.	10.4, 11.7	
Fraxinus lanceolata	35.4	
Carya tomentosa	29.1	

Table 2: Frequency (%), mean cover (%)/quadrat, importance value (I. V.) and change in I. V. for species reported during groundlayer sampling in 2004 and 2010 at Beadles Barrens Nature Preserve, Edwards County, Illinois.

	2004			2010				2004	2010
Species	Freq. (%)	Mean Cover	I. V.	Freq. (%)	Mean Cover	I. V.	Change in I. V.	I. V. Group Total	I. V. Group Total
Woody species									
Parthenocissus quinquefolius	40.0	1.68	8.4	12.0	0.24	2.8	−5.6		
Carya spp.	35.0	1.68	7.8	51.0	1.97	14.7	6.9		
Prunus serotina	33.0	0.94	6.1	18.0	0.12	3.5	−2.6		
Campsis radicans	8.0	1.12	3.1	2.0	0.18	0.9	−2.2		
Symphoricarpos orbiculatus	9.0	0.62	2.3	19.0	0.34	4.3	2.0		
Rubus flagellaris	9.0	0.57	2.2	11.0	1.11	5.1	2.9		
Celtis occidentalis	9.0	0.12	1.4	5.0	0.05	1.0	−0.4		
Rubus pennsylvanicus/ allegheniensis	3.0	0.34	1.1	20.0	1.34	7.3	6.2		
Vitis riparia/vulpina	3.0	0.22	0.8	1.0	0.03	0.3	−0.5		
Quercus alba	2.0	0.16	0.6	2.0	0.01	0.4	−0.2		
Ulmus alata	4.0	0.07	0.6				−0.6		
Toxicodendron radicans	1.0	0.16	0.4				−0.4		
Ulmus rubra	1.0	0.16	0.4				−0.4		
Quercus velutina	2.0	0.01	0.3	3.0	0.21	1.1	0.8		
Celastrus scandens	1.0	0.03	0.2	3.0	0.02	0.6	0.4		
Diospyros virginiana	1.0	0.01	0.2	3.0	0.02	0.6	0.4		
Sassafras albidum				1.0	0.01	0.2	0.2		
Euonymus atropurpureus				1.0	0.03	0.3	0.3		
Rosa carolina				2.0	0.06	0.5	0.5	35.9	43.6
Graminoids									
Carex spp.	76.0	10.13	28.8	65.0	2.10	17.5	−11.3		
Muhlenbergia sobolifera	5.0	0.50	1.6	4.0	0.02	0.8	−0.8		
Dichanthelium acuminatum	6.0	0.33	1.4	4.0	0.02	0.8	−0.6		
Schizachyrium scoparium	4.0	0.47	1.4	1.0	0.03	0.2	−1.2		
Panicum capillare	5.0	0.03	0.7				−0.7		
Elymus virginicus	3.0	0.17	0.7	1.0	0.03	0.2	−0.5		
Elymus villosus	1.0	0.01	0.2	9.0	0.10	1.9	1.7		
Danthonia spicata	1.0	0.03	0.2	1.0	0.03	0.3	0.1		
Agrostis perennans	1.0	0.01	0.2				−0.2		
Muhlenbergia schreberi	1.0	0.03	0.2				−0.2		
Agrostis hyemalis				3.0	0.02	0.6	0.6		
Elymus hystrix				1.0	0.01	0.2	0.2	35.4	22.5
Native perennials									
Helianthus divaricatus	32.0	9.46	21.6	89.0	20.52	73.1	51.5		
Ageratina altissima	29.0	5.17	13.4	31.0	1.69	10.3	−3.1		
Oxalis fontana	52.0	1.34	9.3	7.0	0.04	1.4	−7.9		
Solidago ulmifolia	18.0	1.79	5.7	44.0	3.06	16.4	10.7		
*Eupatorium sero*tinum	22.0	1.14	5.2				−5.2		
Phytolacca americana	14.0	1.40	4.5				−4.5		
Galium circaezans	23.0	0.34	3.7	50.0	0.38	10.1	6.4		
Dioscorea quaternata	8.0	0.74	2.4	1.0	0.03	0.3	−2.1		
Geum canadense	8.0	0.47	1.9	5.0	0.03	1.0	−0.9		
Viola pratincola/sororia	9.0	0.32	1.8	3.0	0.02	0.5	−1.3		
Porteranthus stipulatus	4.0	0.47	1.4	10.0	0.96	4.5	3.1		

Table 2: Continued.

Species	2004 Freq. (%)	2004 Mean Cover	2004 I. V.	2010 Freq. (%)	2010 Mean Cover	2010 I. V.	Change in I. V.	2004 I. V. Group Total	2010 I. V. Group Total
Lactuca floridanam	3.0	0.19	0.8	2.0	0.01	0.4	−0.4		
Coreopsis tripteris	2.0	0.19	0.6	3.0	0.21	1.1	0.5		
Solidago canadensis	2.0	0.01	0.3	5.0	0.10	1.2	0.9		
Penstemon digitalis	2.0	0.01	0.3	1.0	0.01	0.2	−0.1		
Aristocholochia serpentaria	1.0	0.03	0.2	1.0	0.01	0.2	0.0		
*Sanicula ordorat*a				17.0	0.11	3.4	3.4		
Verbesina helianthoides				4.0	0.34	1.7	1.7		
Polygonatum commutatum				2.0	0.04	0.5	0.5		
Aster pilosus				1.0	0.03	0.3	0.3		
Antenoron virginianum				1.0	0.01	0.2	0.2		
Monarda fistulosa				1.0	0.01	0.2	0.2		
Others (4)	5.0	0.10	1.2				−1.2	74.3	127.0
Native annuals and biennials									
Acalypha virginica	72.0	6.41	21.4				−21.4		
Acalypha gracilens	40.0	1.86	8.7	21.0	0.11	4.1	−4.6		
Hedeoma pulegeoides	26.0	0.41	4.2	4.0	0.02	0.8	−3.4		
Sanicula canadensis	23.0	0.54	4.1				−4.1		
Chenopodium standleyanum	18.0	0.57	3.4				−3.4		
Bidens bipinnata	9.0	0.17	1.5	1.0	0.01	0.2	−1.3		
Hackelia virginiana	5.0	0.20	1.0				−1.0		
Ambrosia trifida	2.0	0.19	0.6	1.0	0.01	0.2	−0.4		
Paronychia fastigiata	4.0	0.17	0.8				−0.8		
Lactuca canadensis	5.0	0.05	0.8				−0.8		
Rudbeckia triloba				2.0	0.04	0.5	0.5		
Others (5)	8.0	0.08	1.4				−1.4	47.9	5.8
Non-natives									
Fallopia convolvulus	14.0	0.27	2.4	2.0	0.04	0.5	−1.9		
Lonicera japonica	7.0	0.16	1.2				−1.2		
Setaria faberi	7.0	0.06	1.0				−1.0		
Commelina communis	3.0	0.19	0.8				−0.8		
Chenopodium album				3.0	0.02	0.6	0.6		
Others (4)	6.0	0.07	1.1				−1.1	6.5	1.1

the surveys. In 2010, groundlayer species richness decreased to 55 species. Mean species richness/quadrat decreased from 7.4 to 5.8 and mean cover/quadrat decreased from 54.35% to 37.88%. The mean CC increased to 3.2 and the FQI increased to 23.4. Evenness remained constant at 0.83 while diversity declined to 3.05. Changes in mean CC, species richness/quadrat and mean cover/quadrat were significant at 0.05.

The combined I.V. of woody groundlayer species increased slightly from 35.9 to 43.6 (Table 2). Most of the increase can be attributed to *Carya* spp. and *Rubus pensilvanicus* Poir. and *R. allegheniensis* Porter (blackberries). *Parthenocissus quinquefolia* (L.) Planch. (Virginia creeper) had a decrease in I.V. of 5.6. Three species encountered in 2004, *Toxicodendron radicans* (L.) Kuntze, *Ulmus altata* Michx., and *U. rubra* Muhl., were not recorded in 2010 whereas *Euonymus atropurpureus* Jacq. was recorded only in 2010.

As a group, native perennial forbs experienced the largest increase in I.V. with six species being added and 6 species being lost in the 2010 survey (Table 2). Much of increase in I.V. can be attributed to *Helianthus divaricatus*. Its frequency increased from 32% to 89%, mean percent cover/quadrat increased from 9.46 to 20.52 and its I.V. increased from 21.6 to 73.1. *Solidago ulmifolia* and *Galium circaezans* L. (wild licorice) also experienced a considerable increase in I.V. *Ageratina altissima* and *Oxalis fontana* experienced declines.

The I.V. of native annuals and biennials decreased dramatically from 47.9 to 5.8 with only five species recorded in 2010, 15 being recorded for 2004 (Table 2). *Acalypha virginica*, with an I.V. of 21.4 in 2004 was not reported in 2010 while the I.V. for *A. gracilens* Gray (slender three-seeded mercury) declined by nearly 53%. *Rudbecka triloba* L. (brown-eyed Susan), the only species of this group not reported for 2004, had an I.V. of 0.5.

Only eight non-native (exotic) species having a combined importance value of 6.5 were reported in 2004 (Table 2). *Fallopia convolvulus* (L.) (black bindweed) was the most common occurring in 14% of the quadrats. *Lonicera japonica* Thunb. and *Setaria faberi* Herrm. were the only other non-native species to occur in more than 3% of the quadrats. In 2010, the combined importance value of non-native species decreased from 6.5 to 1.1 with only *Fallopia convolvulus* and *Chenopdium album* L. (Lamb's quarter) recorded.

The graminoid species had a large reduction in I. V. with most of that decline attributed to a *Carex* spp. which experienced an I. V. decline of 11.3 (Table 2). *Panicum capillare* L., *Agrostis perennans* (Walter) Tuck., and *Muhlenbergia schreberi* G. F. Gmel. were recorded in only 2004 whereas *Agrostis hyemalis* (Walter) Britton and *Elymus hystrix* L. were recorded only in 2010.

DISCUSSION AND MANAGEMENT IMPLICATIONS

The results of this study indicate that gradual bottom-up thinning combined with prescribed burning may be an efficient and effective method for enhancing native plant species diversity while minimizing risk of invasion by non-native species in degraded open woodland communities, at least on a small scale. At Beadles Barrens, a degraded woodland community with a nearly-closed canopy and little herbaceous diversity has been shifted toward a more open woodland with a herbaceous-dominated groundlayer in six years with a minimal amount of labor and material costs. Tree density in the study area had been reduced by 37.1%. More than 90% of the area burned during each fire, but there was considerable variation in the intensity of the burns. Prior to initiating management, the thick leaf litter prevented thorough drying of the lower layers of decaying leaf litter except under exceptionally dry conditions. Because of the thick leaf litter and light rain that fell a few days prior to the 2003 burn only the uppermost layers of leaf litter were consumed in many areas. It was not until the 2005 burn that most of the leaf litter was consumed exposing large contiguous patches of bare soil. Burns conducted in 2009 and 2010 consumed nearly all the fine to moderately course fuels and exposed bare soil throughout the entire study area. Of the four burns, the 2009 burn was the most intense, but even then was probably not of sufficient intensity to result in substantial mortality of trees > 10.0 cm dbh (Taft 2005). Thus, reduction in tree density observed during the course of the study likely would not have occurred without thinning

Over the course of the study, the herbaceous component has shifted from a predominance of native annuals and biennials to native perennial forbs. The increase of perennial forbs including *Helianthus divaricatus*, *Solidago ulmifolia*, *Coreopsis tripteris* L. (tall tickseed), *Porteranthus stipulatus* (Muhl.) Britt. (Indian physic), *Verbesina helianthoides* Michx. (yellow crownbeard) and *Rosa carolina* L. (Carolina rose) is important as an increased frequency of the summer-flowering native perennial forbs may result in longer term changes in the groundlayer composition compared to annual species which can fluctuate with disturbance (Hutchinson et al. 2005).

Although herbaceous recovery has occurred, many species, such as *Schizachyrium scoparium* (Michx.) Nash (little blue stem) and *Liatris pyncostachya* Michx. (prairie blazing star) that are abundant in the high quality area across the road are still absent or present in only very low numbers in the study area. Among the graminoids reported in the study, only *Elymus villosus* Muhl. (hairy wild rye) experienced a substantial increase in frequency during the study. Some studies have suggested that a more closed-canopy is more favorable for forbs but that sites with more open canopies tend to have more grasses in the herbaceous layer (Nuzzo et al. 1996, Taft 2002). Tree density in the study area had been reduced by 37.1%; however, the thinning has removed mostly understory and subcanopy trees and the larger hickories that were girdled in 2009 lived through most of that growing season, so the full influence of girdling on groundlayer vegetation may not have been apparent after only one growing season. The treatments applied in this study have substantially increased the intensity of mid-morning, mid-afternoon and filtered sunlight over much of the study area, but direct mid-day sunlight on the forest floor remains patchy. As a result, the light intensity and/or solarization effect may be sufficient to promote establishment and growth of certain perennials, but not appreciable recruitment of more sun-dependent species, such as native perennial grasses or oaks (Taft 2005, Hutchinson 2006). Thus, complete restoration of sites similar to the study area is likely to take a decade or more even though a high quality area is nearby to facilitate seed migration.

It should be noted that the degradation of the study area at Beadles Barrens is thought to be due primarily to fire suppression as no timber harvests or grazing had occurred on the site for at least 50 years prior to management. The study area also had a low abundance of non-native species and fire-induced sprouting species, such as *Sassafras albidum* (Nutt.) Nees or *Rubus* spp., prior to management. These factors substantially reduced the effort necessary to affect significant positive changes. Sites with infestations of non-native or sprouting species would likely require considerably more effort to restore and control of such species should probably be undertaken prior to initiating and burning and thinning regime (Taft 2005).

LITERATURE CITED

Anderson, R. C., S. S. Dhillion, and T. M. Kelley. 1996. Aspects of the ecology of an invasive plant, garlic mustard (*Allaria petiolata*), in central Illinois. Restoration Ecology 4:181–191.

Anderson, R. C., J. S. Fralish, and J. M. Baskin. 1999. Savannas, barrens, and rock outcrop plant communities of North America. Cambridge University Press, Cambridge, UK. 484 pp.

Bailey, A. W. and C. E. Poulton. 1968. Plant communities and environmental relationships in a portion of the Tillamook burn, Northwest Oregon. Ecology 49:1–13.

Daubenmire, R. 1959. A canopy coverage method of vegetation analysis. Northwest Science 33:43–64.

Dodson, E. K. 2004. Monitoring change in exotic plant abundance after fuel reduction/restoration treatments in ponderosa pine forests of western Montana. M. S. Thesis. The University of Montana, Missoula, Montana.

Edgin, B. R. 1996. Barrens of presettlement Lawrence County, Illinois. pp. 59–65, Charles Warwick (ed) *in* Proceedings of the 15th North American Prairie Conference, October 23–26, 1996, St. Charles, Illinois.

Edgin, B. R. and J. E. Ebinger. 1997. Barrens and the forest-prairie interface in presettlement Crawford County, Illinois. Castanea 62:260–267.

Edgin, B. and J. E. Ebinger. 2008. *Carya* (hickories) in the ecotonal forests of the Illinoian till plain. Erigenia 22:45–55.

Edgin, B. R., R. Beadles, and J. E. Ebinger. 2005. Vascular flora of Beadles Barrens Nature Preserve, Edwards County, Illinois. Castanea 75:47–58.

Elliott, K. J. and J. M. Vose. 2010. Short-term effects of prescribed fire on mixed oak forests in the southern Appalachians: vegetation response. Journal of the Torrey Botanical Society 137:49–66.

Griffis, K. L., J. A. Crawford, M. R. Wagner, and W. H. Moir. 2001. Understory response to management treatments in northern Arizona ponderosa pine forests. Forest Ecology and Management 146:239–245.

Hobbs, R. J. and L. F. Huennke. 1992. Disturbance, diversity and invasion: implications for conservation. Conservation Biology 6:324–337.

Hohlubner, E. G. and J. B. Fehrenbacher. 1972. Soil survey of Edwards and Richland Counties, Illinois. U. S. Department of Agriculture, Soil Conservation Service, Washington, D. C.

Huddle, J. A. and S. G. Pallardy. 1966. Effects of long-term annual and periodic burning on tree survival and growth in a Missouri Ozark oak-hickory forest. Forest Ecology and Management 82:1–9.

Hutchinson, T. 2006. Fire and the herbaceous layer of eastern oak forests. Pages 136–149 *in* Prodeedings of conference Fire in eastern oak forests: Delivering science to land managers,

Hutchinson, T. F., R. E. J. Boerner, S. Sutherland, E. K. Sutherland, M. Ortt, and L. R. Iverson. 2005. Prescribed fire effects on the herbaceous layer of mixed-oak forests. Canadian Journal of Forest Research 35:877–890.

Magurran, A. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey. 192 pp.

McClain, W. E., B. R. Edgin, T. L. Esker, and J. E. Ebinger. 2007. Two closed-canopy barren communities in east-central Illinois. Northeastern Naturalist 14:35–50.

Mohlenbrock, R. H. 2002. Vascular flora of Illinois. University of Illinois Press, Carbondale, Illinois. 282 pp.

Nielsen, S., C. Kirschbaum, and A. Haney. 2003. Restoration of midwest oak barrens: structural manipulation of process-only? Conservation Biology 7:10. [online] URL:http://www.consecol.org/vol7/iss2/art10.

Nuzzo, V. 1986. Extent and status of Midwestern oak savanna: presettlement and 1985. Natural Areas Journal 6:149–166.

Nuzzo, V. A., W. McClain, and T. Strole. 1996. Fire impact on groundlayer flora in a sand forest 1990–1994. The American Midland Naturalist 136:207–221.

Peterson, D. W. and P. B. Reich. 2001. Prescribed fire in oak savannas: Fire frequency effects on stand structure and dynamics. Ecological Applications 11:914–927.

Phillips, R., T. Hutchinson, L. Brudnak, and T. Waldrop. 2007. Fire and fire surrogate treatments in mixed-oak forests: effects on herbaceous layer vegetation. Pages 1–11 *in* Proceedings of USDA Forest Service RMRS-P-46.

Shannon, C. E. and W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Urbana, Illinois. 117 pp.

Taft, J. B. 2002. Vegetation composition, structure, and diversity patterns of two dry sandstone barrens in southern Illinois. Castanea 67:343–368.

Taft, J. B. 2005. Fire effects on structure, composition, and diversity in a south-central Illinois flatwoods remnant. Castanea 70(4):298–313.

Taft, J. B., G. S. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for vegetation in Illinois, a method for assessing vegetation integrity. Erigenia 15:3–95.

Testor, J. R. 1989. Effects of fire frequency on oak savanna in east-central Minnesota. Bulletin of the Torrey Botanical Club 116:134–144.

White, A. S. 1986. Prescribed burning for oak savanna restoration in central Minnesota. Res. Pap. NC-266. St. Louis, MN: U. S. Department of Agriculture, Forest Service, North Central Forest Experimental Station. 12 pp.

Erigenia, Number 25, Spring 2012, pp 23–35

Vegetation of Sand Ridge Savanna Nature Preserve Will County, Illinois

Loy R. Phillippe[1], Paul B. Marcum[1], and John E. Ebinger[1]*

Abstract: Sand Ridge Savanna Nature Preserve, 4 km east of Braidwood, Will County, Illinois, has a diverse assemblage of sand communities. The dry-mesic sand savanna was dominated by *Quercus velutina* [importance value (IV) of 153.3 (possible 200)] followed by *Q. alba.* Wet sand prairies occurred in the swales between the dunes and were dominated by *Carex pellita* (IV of 37.8) with *Onoclea sensibilis*, *Eleocharis palustris*, *Spartina pectinata*, *Carex scoparia*, and *Thelypteris palustris* common. *Scleria triglomerata*, *Sorghastrum nutans*, and *Agrostis gigantea* were the dominant grass-like plants of the wet-mesic sand prairie while *Potentilla simplex*, *Platanthera flava* var. *herbiola*, and *Solidago altissima* were the important forbs. The sedge meadow was dominated by *Carex haydenii/stricta*, two species of *Persicaria,* and *Calamagrostis canadensis*. A total of 337 vascular plant taxa were found on the Preserve including 37 exotic taxa. One state-endangered species, *Hypericum adpressum*, and two state-threatened species, *Platanthera flava* var. *herbiola* and *Drosera intermedia* were encountered.

Introduction

Sand deposits, which account for nearly 5% of Illinois' land surface, are common in the northern half of Illinois due to erosional events associated with Wisconsin glaciation (King 1981, Schwegman 1973, Willman and Frye 1970). The sand deposits remained after glacial lakes were drained about 14,500 years ago as glacial moraines and ice dams were breached resulting in the Kankakee Torrent (Willman 1973). One of the most extensive sand areas is the Kankakee sand deposits in northeastern Illinois in parts of Grundy, Iroquois, Kankakee, and Will Counties.

Within the Kankakee sand deposits, Sand Ridge Savanna Nature Preserve is a unique area that contains some of the best quality dry-mesic sand savanna in northern Illinois. Also, in some of the shallow depressions and swales between the dunes, wet sand communities exist. These rare communities, including sedge meadows, wet sand prairies, and wet-mesic sand prairies were found in the Preserve and are of high natural quality. The present study was undertaken to determine vascular plant species composition, vegetation structure, and floristic quality of the major natural plant communities of this Preserve.

[1] Illinois Natural History Survey, 1816 South Oak Street, Champaign, Illinois 61820.
*corresponding author (jeebinger@eiu.edu)

Study Site

The 90 ha Sand Ridge Savanna Nature Preserve is located in the southwestern corner of Will County about 4 km east of Braidwood, and 20 km south of Joliet (W½ of S14, T12N, R9E; 41.25655°N, −88.16477°W). This site was originally referred to as the "Munch Area" by the original Illinois Natural Areas Inventory (White 1978). Presently owned by the Forest Preserve District of Will County, the Preserve is located in the Kankakee Sand Area Section of the Grand Prairie Natural Division (Schwegman 1973). The Preserve, dedicated in 1993, contains the remnants of a dry-mesic sand savanna of good natural quality (McFall and Karnes 1995). An extensive field, cultivated before the land was purchased by the Will County Forest Preserve District, was seeded to mesic sand prairie species. Before the purchase, most of the area that now constitutes this Preserve was used for grazing while much of the eastern third was used for row-crop agriculture.

The Preserve is situated near the edge of former glacial Lake Wauponsee that drained about 14,500 years ago during the Kankakee Torrent leaving sandy beaches and near shore sand deposits (Willman and Frye 1970). These sands were reworked by wind creating the present dune and swale topography. Characteristic sand savanna and sand prairie vegetation became established during the Hypsithermal period about 8,000 years ago (King 1981).

The soils of the low areas between the dunes are Granby fine sandy loams that are on out-wash plains, are poorly drained, and are relatively high in organic material, while the low dune soils are Oakville fine sands that developed from windblown sediments, are excessively well drained, and low in organic material (Hanson 2004). The climate is continental with warm summers and cold winters. Mean annual precipitation is 98.0 cm, with May having the highest rainfall (11.5 cm). Mean annual temperature is 9.9°C with the hottest month being July (average of 23.6°C), and the coldest being January (average of −5.7°C). Frost-free days range from 141 to 206, with the average being 174 days per year (Midwestern Regional Climate Center 2009; Kankakee, Illinois).

METHODS

Floristic Composition

The Preserve was visited six to ten times each year throughout the growing seasons of 2007 to 2009. During these visits voucher specimens were collected and deposited in the herbarium of the Illinois Natural History Survey, Champaign, Illinois (ILLS). The designation of exotic species follows Mohlenbrock (2002) and Taft et al. (1997). Nomenclature follows Mohlenbrock (2002).

Ground Layer Sampling

In mid-summer of 2009 transects were located randomly along cardinal compass directions within the wet-mesic sand prairie, wet sand prairie, and sedge meadow. Within each of these communities, one or two transects (25 m long) were located (n = 25 or 50 quadrats). Along each transect, 1m^2 quadrats were located alternately along the right and left of transects. A random numbers table was used to determine the distance (0 to 9 m) a quadrat was located from the transect line. Species cover was determined using the Daubenmire (1959) cover class system as modified by Bailey and Poulton (1968). The modified Daubenmire cover scale is as follows: class 1 = 0 to 1%; class 2 ≥ 1 to 5%; class 3 ≥ 5 to 25%; class 4 ≥ 25 to 50%; class 5 ≥ 50 to 75%; class 6 ≥ 75 to 95%; class 7 ≥ 95 to 100%. Only ground layer species rooted within the quadrat frame were recorded. Mean cover was determined for each taxon using the mid-point values for each cover class, while Importance Value (IV) was calculated by summing relative cover and relative frequency.

Overstory Sampling

During summer of 2008, a north/south study area 150 m by 200 m was established in the best quality area of the savanna community and was surveyed by dividing this transect into 48 contiguous quadrats 25 m on a side (3 ha). All living and dead-standing woody individuals ≥ 10.0 cm dbh were identified and their diameters recorded. From these data, living-stem density (stems/ha), basal area (m^2/ha), relative density, relative dominance (basal area), Importance Value (IV), and average diameter (cm) were calculated for each species. Importance Values are calculated as the sum of the relative density and relative dominance (McIntosh 1957). Dead-standing density (stem/ha) and basal area (m^2/ha) were also calculated.

Woody understory composition and density (stems/ha) were determined using nested circular plots 0.0001, 0.001, and 0.01 ha in size with the centers located at 25 m intervals along randomly located north/south transects within the study area (24 center points). Four additional 0.0001 ha circular plots were located 6 m from the center point of each plot center along cardinal compass directions. In the 0.0001 ha plots, woody seedlings (≤ 50 cm tall) were counted; in the 0.001 ha circular plots small saplings (> 50 cm tall and < 2.5 cm dbh) were recorded; and in the 0.01 ha circular plots large saplings (2.5 to 9.9 cm dbh) were tallied.

RESULTS

Floristic Composition

The Preserve supports a total of 337 vascular plant taxa in 77 families (Appendix). Fern, fern-allies, and gymnosperms were represented by 6 taxa in 5 families. Of the remaining taxa, 90 were monocots in 12 families, and 241 were dicots in 60 families. Non-native (exotic) species accounted for 37 taxa, about 11% of the species collected. Predominant plant families were Asteraceae (49 species), Poaceae (39), and Cyperaceae (25). The only state endangered species found was *Hypericum adpressum* (creeping St. John's-wort), while two state threatened species were encountered: *Drosera intermedia* (narrow-leaved sundew) and *Platanthera flava* var. *herbiola* (tubercled orchid) (Illinois Endangered Species Protection Board 2005).

Dry-mesic Sand Savanna

The overstory of the dry-mesic sand savanna averaged 213.3 stems/ha with a basal area of 20.041 m^2/ha. *Quercus velutina* (black oak) dominated the canopy with 145 stems/ha, nearly 75% of the basal area (17.065 m^2/ha), an IV of 153.3, and an average diameter of 33.7 cm (Table 1). *Quercus alba* (white oak), the only other tree species that entered the canopy, averaged 28.7 stems/ha, and an IV of 25.6. *Quercus velutina* had an unusual size class distribution, dominating the 10 to 20 and 50+ diameter classes, probably the result of past logging or fire. The extent of multiple-stemmed individuals (12.6

coppice stems/ha) also indicated that the site had been logged in the past, while the large number of small diameter stems of *Sassafras albidum* (sassafras) indicates that management fires have not been used within the past 7 to 10 years, or that the fires were of low intensity.

Numerous seedlings and small saplings were found in the understory; woody seedlings averaged 51,751 stems/ha and small saplings averaged 29,542 stems/ha (Table 2). Large saplings were not common, averaged only 133 stems/ha, indicating some low intensity management fires have been used recently to keep the understory open. The tree species *Sassafras albidum, Quercus velutina, Q. alba, and Prunus serorina* (black cherry) dominated the woody seedlings and saplings. Many were multiple-stemmed sprouts from old root crowns. The remaining understory species were mostly shrubs with *Rubus* spp. (blackberries and raspberries), *Rosa carolina* (pasture rose), and *Toxicodendron radicans* (poison ivy) the most important. The only exotic woody species encountered in the plots was *Elaeagnus umbellata* (autumn olive).

Wet Sand Prairie

The wet sand prairie surveyed was less than 0.25 ha and situated in the swales between the forested dunes (Table 3). The surrounding closed savanna allowed for full sunlight for less than half of the day. *Carex pellita* (woolly sedge) dominated with an IV of 37.8. Other common grass-like species included *Eleocharis palustris* (marsh spikerush), *Spartina pectinata* (cord grass), and *Carex scoparia* (sedge), that ranked third, forth, and fifth in IV, respectively. Two fern species, *Onoclea sensibilis* (sensitive fern) and *Thelypteris palustris* (marsh fern), were included in the six most important taxa found. Of the 37 species encountered in the wet sand prairie plots all were native wet prairie or sedge meadow species except for the exotic *Poa pratensis* (Kentucky blue grass) that was found in one plot.

Sedge Meadow

Near the southeastern edge of the Preserve are a few small sedge meadows, each about 0.5 ha in size (Table 4). The sedge meadow surveyed was dominated by *Carex haydenii* (Hayden's sedge), and probably some *C. stricta* (tussock sedge), with an IV of 50.2 and a mean cover of 29.46%. The few flowering stems found were all identified to *C. haydenii*, though both species were probably present. These species are difficult to separate based on vegetative material, and both formed low hummocks on which many of the other species grow. Sterile material of *Persicaria amphibium* and *P. coccinea* (smartweeds) together accounted for an IV of 36.6, and a mean cover of 18.94, while *Calamagrostis canadensis* (bluejoint grass) was the only other species present with an IV > 9.0 (Table 4). Of the 39 species encountered in the plots all were native wet prairie or sedge meadow species.

Wet-mesic Sand Prairie

The wet-mesic sand prairie examined was more than 1.5 ha, and was located adjacent to the sedge meadow studied. This prairie had high diversity with 97 species occurring in the plots of which only 20 species had IV's > 4.0 (Table 5). The important grass-like plants were *Scleria triglomerata* (nut rush) which ranked second with an IV of 10.5, *Sorghastrum nutans* (Indian grass) which ranked fifth in IV (9.0), while *Agrostis gigantea* (red top) ranked sixth (IV of 7.8). Important forbs included *Potentilla simplex* (common cinquefoil) which was first (IV of 21.0), the state-threatened *Platanthera flava* var. *herbiola* was third (IV of 9.8), and *Solidago altissima* (tall goldenrod) was forth (IV of 9.7). Nearly all of the species encountered in the plots were native wet to wet-mesic prairie species, only six being exotics, the most important being *Achillea millefolium* (IV of 4.8) and *Poa pratensis* (IV of 2.8).

Table 1: Density by diameter class (stems/ha), basal area (m^2/ha), relative density, relative dominance, importance value, and average diameter for the tree species recorded in a dry-mesic savanna at the Sand Ridge Savanna Nature Preserve, Will County, Illinois.

	Diameter Classes (cm)						Basal				Av.
Species	10–19	20–29	30–39	40–49	50+	Total #/ha	Area m^2/ha	Rel. Den.	Rel. Dom.	IV	Diam. (cm)
Quercus velutina	57.3	11.3	10.7	26.7	39.3	145.3	17.065	68.1	85.2	153.3	33.7
Quercus alba	5.3	8.0	11.0	2.7	1.7	28.7	2.449	13.4	12.2	25.6	30.9
Prunus serotina	25.7	–	–	–	–	25.7	0.331	12.1	1.6	13.7	12.4
Sassafras albidum	13.3	0.3	–	–	–	13.6	0.196	6.4	1.0	7.4	13.2
Totals	101.6	19.6	21.7	29.4	41.0	213.3	20.041	100.0	100.0	200.0	

Table 2: Density (stems/ha) of woody seedlings, small saplings, and large saplings encountered in a dry-mesic savanna at Sand Ridge Savanna Nature Preserve, Will County, Illinois. (*exotic species)

Species	Seedlings	Small Saplings	Large Saplings
Sassafras albidum	14666.7	8166.7	12.5
Quercus velutina	9500.0	2958.3	70.8
Rubus allegheniensis	8333.3	13833.3	–
Rosa carolina	4083.2	–	–
Quercus alba	3666.7	2125.0	12.5
Toxicodendron radicans	3500.0	–	–
Prunus serotina	1416.7	1416.7	37.5
Celastrus scandens	1250.5	583.3	–
Ribes missouriense	833.3	–	–
**Elaeagnus umbellata*	750.0	–	–
Rubus flagellaris	666.7	–	–
Cornus racemosa	583.7	41.7	–
Gaylussacia baccata	416.7	–	–
Rubus occidentalis	416.7	–	–
Spiraea tomentosa	416.7	–	–
Others	1250.0	416.7	–
Totals	51750.9	29541.7	133.3

DISCUSSION

The dry-mesic savannas studied in the Kankakee sand deposits are similar in woody species composition and structure. These include Iroquois County Conservation Area (McDowell et al. 1983, Phillippe et al. 2009), Hooper Branch Nature Preserve (Johnson and Ebinger 1992, 1995, Phillippe et al. 2010), Pembrook Township savannas (Phillippe et al 2011), and Braidwood Dunes and Savanna Nature Preserve (Phillippe et al. 2008) . At all sites *Quercus velutina* was the dominant species and accounted for about 70% or more of the IV, while *Q. alba* was second, with *Prunus serotina* and *Sassafras albidum* sometimes present in low numbers and small diameters.

These sand savannas are different today compared to the early 1800s, mostly due to a reduced fire frequency followed by the total absence of fire in recent decades (Taft 1997). Originally natural fires and those set by early aborigines decreased the extent of woody invasion, while early settlers used fire to maintain open pasture (Ebinger and McClain 1991, McClain and Elzinga 1994). With the decrease in grazing in Illinois by the early 1940s and the increase in home sites and agriculture, the number and intensity of woodland fires dramatically decreased. In those historic savannas the trees had an open-grown appearance with low branches and branch-scars. Presently, a few large, open-grown trees remain in the study plots.

Presently, occasional fires and the droughty conditions have allowed for the perpetuation of oak species. Black and white oaks are reproducing on the site with numerous seedlings and saplings in the understory. Fire has been the management tool of choice in maintaining these sand savanna communities. Johnson and Ebinger (1992, 1995) found that annual burns decrease woody seedling and shrub density, and increased the number of top-killed individuals. They also found that less frequent burning accounted for a higher density of woody understory species, and a higher frequency of some herbaceous species.

Of the herbaceous communities surveyed, all are relatively rare and little information is available concerning species composition and structure. In particular, wet and wet-mesic sand prairies are very uncommon in Illinois. The only published information available for wet sand prairies is a brief description by White and Madany (1978): a community where surface water is present for as much as one-third of the year, particularly in winter and spring; and that wet sand prairie is floristically similar to "black soil" wet prairie with relatively few species present. They list the dominant species as *Calamagrostis canadensis*, *Carex* spp., *Spartina pectinata*, and *Thelypteris palustris*. The wet prairie studied had the same species as dominants except *Calamagrostis canadensis* was missing from the plots.

Wet-mesic sand prairie is also an uncommon community in Illinois, very little information having been published. For this community White and Madany (1978) listed *Andropogon gerardii* (big bluestem), *Calamagrostis canadensis*, *Carex* sp., *Sorghastrum nutans,* and *Spartina pectinata* as the dominant species. Of these species, only *Carex* spp. and

Table 3: Frequency (%), mean cover (% of total area), relative frequency, relative cover, and importance value (IV) of the ground layer species encountered in a wet sand prairie located in a swale between forested dunes at Sand Ridge Savanna Nature Preserve, Will County, Illinois. (*exotic species)

Species	Freq. %	Mean Cover	Rel. Freq.	Rel. Cover	I. V.
Carex pellita	100	14.04	10.6	27.2	37.8
Onoclea sensibilis	76	11.76	8.1	22.7	30.8
Eleocharis palustris	76	4.88	8.1	9.4	17.5
Spartina pectinata	72	2.80	7.6	5.4	13.0
Carex scoparia	72	2.60	7.6	5.1	12.7
Thelypteris patustris	20	3.90	2.1	7.5	9.6
Bidens polylepis	68	0.44	7.2	0.9	8.1
Lycopus americanus	44	1.20	4.7	2.3	7.0
Ludwigia alternifolia	32	1.82	3.4	3.5	6.9
Acer saccharinum	60	0.22	6.4	0.4	6.8
Lycopus uniflorus	48	0.64	5.1	1.2	6.3
Iris shrevei	16	1.92	1.7	3.7	5.4
Lysimachia terrestris	24	1.52	2.5	2.9	5.4
Galium tinctorum	40	0.40	4.3	0.9	5.2
Spiraea tomentosa	16	0.96	1.7	1.9	3.6
Agrimonia parviflora	8	0.62	0.9	1.2	2.1
Vernonia missurica	8	0.62	0.9	1.2	2.1
Boehmeria cylindrica	16	0.08	1.7	0.2	1.9
Hypericum mutilum	12	0.16	1.3	0.3	1.6
Juncus anthelatus	12	0.16	1.3	0.3	1.6
Viola lanceolata	12	0.16	1.3	0.3	1.6
Agrostis hyemalis	12	0.06	1.3	0.1	1.4
Eleocharis wolfii	12	0.06	1.3	0.1	1.4
Epilobium coloratum	12	0.06	1.3	0.1	1.4
Tracaulon sagittatum	12	0.06	1.3	0.1	1.4
Toxicodendron radicans	8	0.14	0.9	0.3	1.2
Agrostis gigantea	8	0.04	0.9	0.1	1.0
Aster praealtus	8	0.04	0.9	0.1	1.0
Asclepias incarnata	4	0.12	0.4	0.2	0.6
Cornus obliqua	4	0.04	0.4	0.2	0.6
**Poa pratensis*	4	0.12	0.4	0.2	0.6
Cardamine parviflora	4	0.02	0.4	–	0.4
Cicuta maculata	4	0.02	0.4	–	0.4
Euthamia gymnospermoides	4	0.02	0.4	–	0.4
Leersia virginica	4	0.02	0.4	–	0.4
Solidago canadensis	4	0.02	0.4	–	0.4
Verbena hastata	4	0.02	0.4	–	0.4
Totals		51.84	100.0	100.0	200.0
Bare ground and litter		45.00			

Sorghastrum nutans were present as dominants in the wet-mesic sand prairie studied. The remaining species were uncommon or not encountered in the plots. Many of these species, however, as well as others reported by White and Madany (1978) did occur in other parts of the sand prairie studied. The high diversity encountered appears to be typical of wet-mesic sand prairies. Presently, the prairie is being invaded by *Elaeagnus umbellata*. This species, and other invading woody species, should be removed by cutting and herbicide treatment.

Sedge meadows are also rare in Illinois, but more common than wet and wet-mesic sand prairies. We have occasionally encountered and studied sedge meadows at Braidwood Dunes and Savanna Nature Preserve in the Kankakee sand deposits (Phillippe et al.

Table 4: Frequency (%), mean cover (% of total area), relative frequency, relative cover, and importance value (IV) of the ground layer species encountered in a sedge meadow at Sand Ridge Savanna Nature Preserve, Will County, Illinois. (*exotic species)

Species	Freq. %	Mean Cover	Rel. Freq.	Rel. Cover	I. V.
Carex haydenii/stricta	100	29.46	13.9	36.3	50.2
Persicaria amphibium/coccinea	96	18.94	13.4	23.2	36.6
Calamagrostis canadensis	96	14.73	13.4	18.1	31.5
Caltha palustris	32	3.21	4.9	3.9	8.8
Boehmeria cylindrica	38	2.71	5.3	3.3	8.6
Lycopus uniflorus	38	2.28	5.3	2.8	8.1
Iris shrevei	26	3.24	3.6	4.0	7.6
Galium triflorum	36	0.58	5.0	0.7	5.7
Lemna minor	32	0.36	4.9	0.4	5.3
Eleocharis palustris	24	0.32	3.4	0.4	3.8
Bidens polylepis	24	0.27	3.4	0.3	3.7
Aster puniceus	12	1.27	1.7	1.6	3.3
Scutellaria lateriflora	18	0.34	2.5	0.4	2.9
Proserpinaca palustris	18	0.09	2.5	0.1	2.6
Thelypteris palustris	10	0.97	1.4	1.2	2.6
Lathyrus palustris	16	0.28	2.2	0.3	2.5
Lysimachia terrestris	16	0.08	2.2	0.1	2.3
Leersia oryzoides	12	0.21	1.7	0.3	2.0
Carex sartwellii	8	0.38	1.0	0.5	1.5
Cephalanthus occidentalis	4	0.60	0.5	0.7	1.2
Epilobium coloratum	8	0.09	1.0	0.1	1.1
Carex buxbaumii	8	0.04	1.0	–	1.0
Solidago gigantea	4	0.31	0.5	0.4	0.9
Spiraea alba	4	0.31	0.5	0.4	0.9
Lycopus americanus	6	0.03	0.8	–	0.8
Campanula aparinoides	4	0.02	0.5	–	0.5
Ludwigia palustris	4	0.02	0.5	–	0.5
Eupatorium perfoliatum	2	0.06	0.3	0.1	0.4
Euthamia gymnospermoides	2	0.06	0.3	0.1	0.4
Oxypolis rigidior	2	0.06	0.3	0.1	0.4
Pilea pumila	2	0.06	0.3	0.1	0.4
Pycnanthemum virginianum	2	0.06	0.3	0.1	0.4
Cardamine bulbosa	2	0.01	0.3	–	0.3
Carex pellita	2	0.01	0.3	–	0.3
**Mentha arvensis*	2	0.01	0.3	–	0.3
Scirpus atrovirens	2	0.01	0.3	–	0.3
Verbena hastata	2	0.01	0.3	–	0.3
Totals		81.49	100.0	100.0	200.0
Bare ground and litter		22.00			

2008) the Richardson Wildlife Foundation in the Green River lowlands sand deposits of Lee County (Handel et al. 2003), and Matanzas Nature Preserve in the Illinois River sand deposits of Mason County (Feist et al. 2008). In all of these sedge meadows the species composition and vegetation structure was similar with the *Carex haydenii/stricta* complex dominating and forming hummocks on which many other species grow.

Acknowledgments

We would like to thank the Illinois Department of Natural Resources for a Wildlife Preservation Fund

Table 5: Frequency (%), mean cover (% of total area), relative frequency, relative cover, and importance value (IV) of the ground layer species encountered in wet-mesic sand prairie at Sand Ridge Savanna Nature Preserve, Will County, Illinois. Species with importance values of <1.5 are listed as others. (*exotic species)

Species	Freq. %	Mean Cover	Rel. Freq.	Rel. Cover	I. V.
Potentilla simplex	94	25.20	4.0	17.0	21.0
Scleria trigomerata	84	10.15	3.6	6.9	10.5
Platanthera flava var. herbiola	78	9.54	3.4	6.4	9.8
Solidago altissima	70	9.99	3.0	6.7	9.7
Sorghastrum nutans	70	8.85	3.0	6.0	9.0
Agrostis gigantea	94	5.69	4.0	3.8	7.8
Solidago missouriensis	72	6.30	3.1	4.2	7.3
Parthenium integrifolium	34	6.13	1.5	4.1	5.6
Comandra umbellata	90	2.08	3.9	1.4	5.3
Rudbeckia fulgidia	62	3.57	2.7	2.4	5.1
Lysimachia lanceolata	80	2.27	3.4	1.5	4.9
**Achillea millefoilium*	78	2.11	3.4	1.4	4.8
Dichanthelium clandestinum	32	4.69	1.4	3.2	4.6
Euphorbia corollata	66	2.30	2.8	1.6	4.4
Carex pensylvanica	46	3.24	2.0	2.2	4.2
Dichanthelium acuminatum	72	1.69	3.1	1.1	4.2
Euthamia gymnospermoides	48	3.15	2.1	2.1	4.2
Helianthus mollis	26	4.24	1.1	2.9	4.0
Krigia biflora	46	2.95	2.0	2.0	4.0
Viola sagittata	78	0.89	3.4	0.6	4.0
Equisetum arvense	60	0.50	2.6	0.3	2.9
Luzula bulbosa	62	0.31	2.7	0.2	2.9
Coreopsis tripteris	22	2.79	0.9	1.9	2.8
**Poa pratensis*	44	1.35	1.9	0.9	2.8
Carex conoidea	48	0.84	2.1	0.6	2.7
Liatris spicata	26	1.97	1.1	1.3	2.4
Agrimonia parviflora	20	1.97	0.9	1.3	2.2
Silphium integrifolium	22	2.00	0.9	1.3	2.2
Pedicularis canadensis	16	1.89	0.6	1.3	1.9
Tradescantia ohiensis	36	0.63	1.5	0.4	1.9
Cornus obliqua	18	1.40	0.8	0.9	1.7
Fragaria virginiana	26	0.96	1.1	0.6	1.7
Lactuca floridana	26	0.67	1.1	0.5	1.6
Rosa carolina	28	0.54	1.2	0.4	1.6
Rubus flagellaris	22	0.94	0.9	0.6	1.5
Sisyrinchium albidum	30	0.25	1.3	0.2	1.5
Others (61 species)		14.25	21.5	9.8	31.3
Totals		148.29	100.0	100.0	200.0
Bare ground and litter		11.34			

grant to complete this study, and their staff for help and encouragement, and the staff of the Forest Preserve District of Will County for their help.

Literature Cited

Bailey, A. W. and C. E. Poulton. 1968. Plant communities and environmental relationships in a portion of the Tillamook burn, northwestern Oregon. Ecology 49:1–13.

Daubenmire, R. 1959. A canopy coverage method of vegetation analysis. Northwest Science 33:43–64.

Ebinger, J. E. and W. E. McClain. 1991. Forest succession in the prairie peninsula of Illinois. Illinois Natural History Survey Bulletin 34:375–381.

Feist, M. A., M. J. Morris, M. L. R. Phillippe, J. E. Ebinger, and W. E. McClain. 2008. Sand prairie communities of Matanzas Nature Preserve, Mason County, Illinois. Castanea 73:177–187.

Handel, W. C., L. R. Phillippe, and J. E. Ebinger. 2003. Floristic assessment of sand prairies and sedge meadows, Lee County, Illinois. The Prairie Naturalist 35:33–46.

Hanson, K. D. 2004. Soil survey of Will County, Illinois. United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Illinois Agricultural Experiment Station, Champaign, Illinois.

Illinois Endangered Species Protection Board 2005. Checklist of Endangered and Threatened Animals and Plants of Illinois. Endangered Species protection Board, Springfield, Illinois.

Johnson, K. C. and J. E. Ebinger. 1992. Effects of prescribed burns on the woody vegetation of a dry sand savanna, Hooper Branch Nature Preserve, Iroquois County, Illinois. Transactions of the Illinois State Academy of Science 85:105–111.

Johnson, K. C. and J. E. Ebinger. 1995. Effects of different fire regimes on the ground layer vegetation of a dry sand savanna, Hooper Branch Nature Preserve, Iroquois County, Illinois. Erigenia 14:37–40.

King, J. E. 1981. Late Quaternary vegetational history of Illinois. Ecological Monographs 51:43–62.

McClain, W. E. and S. L. Elzinga. 1994. The occurrence of prairie and forest fires in Illinois and other Midwestern states, 1679 to 1854. Erigenia 13:79–90.

McDowell, B., J. Newman, and J. Ebinger. 1983. Survey of the woody vegetation of the Kankakee Sand Area Section of Indiana and Illinois. Proceeding of the Indiana Academy of Science 93:187–193.

McFall, D. and J. Karnes. 1995. editors. A directory of Illinois Nature Preserves. Volume 2. Northwestern, Central and Southern Illinois. Illinois Department of Natural Resources, Springfield, Illinois.

McIntosh, R. P. 1957. The York Woods. A case history of forest succession in southern Wisconsin. Ecology 38:29–37.

Midwestern Regional Climate Center. 2009, http:/mcc.sws.uiuc.edu

Mohlenbrock, R. H. 2002. Vascular flora of Illinois. Southern Illinois University Press, Carbondale and Edwardsville, Illinois.

Phillippe, L. R., D. T. Busemeyer, P. B. Marcum, M. A. Feist, and J. E. Ebinger. 2008. Prairie and savanna vegetation of Braidwoods Dunes and Savanna Nature Preserve, Will County, Illinois. Castanea 73:1–15.

Phillippe, L. R., M. A. Feist, R. L. Larimore, D. T. Busemeyer, P. B. Marcum, C. J. Carroll, J. L. Ellis, and J. E. Ebinger. 2009. Composition and structure of the ground layer vegetation at Iroquois County Conservation Area, northeastern Illinois. Phytologia 91:301–327.

Phillippe, L. R., M. A. Feist, R. L. Larimore, D. T. Busemeyer, P. B. Marcum, C. J. Carroll-Cunningham, J. L. Ellis, and J. E. Ebinger. 2010. Vegetation of Hooper Branch Nature Preserve, Iroquois County, Illinois. Northeastern Naturalist 17:261–272.

Phillippe, L. R., M. A. Feist, D. T. Busemeyer, P. B. Marcum, C. J. Carroll-Cunningham, G. Spyreas, and J. E. Ebinger. 2011. Vegetation of forest and savanna communities in northeastern Illinois. Southwestern Naturalist 56:54–60.

Schwegman, J. E. 1973. Comprehensive plan for the Illinois nature preserves system. Part 2. The natural divisions of Illinois. Illinois Nature Preserves Commission, Rockford, Illinois.

Taft, J. B. 1997. Savanna and open woodland communities. pp. 24–54 ***in*** M. W. Schwartz, ed., Conservation in highly fragmented landscapes. Chapman and Hall, New York.

Taft, J. B., G. S. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for vegetation in Illinois, a method for assessing vegetation integrity. Erigenia 15:1–95.

White, J. 1978. Illinois Natural Areas Inventory. Technical report. Volume I. Survey methods and results. Illinois Natural Areas Inventory, Urbana, Illinois.

White, J. and M. H. Madany. 1978. Classification of natural communities in Illinois. pp. 310–405 *In* J. White, ed., Illinois natural areas inventory. Technical report. Illinois Natural Areas Inventory, Urbana, Illinois.

Willman, H. B. 1973. Geology along the Illinois waterway - a basis for environmental planning. Illinois State Geological Survey Circular 478, Urbana, Illinois.

Willman, H. B. and J. C. Frye. 1970. Pleistocene stratigraphy of Illinois. Illinois State Geological Survey Bulletin 94:1–204.

APPENDIX

Vascular plant species encountered at Sand Ridge Savanna Nature Preserve, Will County, Illinois are listed alphabetical by family under the major plant groups. Collecting numbers are preceded by the initial of the collector (P = Loy R. Phillippe). Specimens are deposited in the Illinois Natural History Survey Herbarium (ILLS), Champaign, Illinois. (*exotic species)

FERN AND FERN-ALLIES

DENNSTAEDTIACEAE
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) (L.) Underw.: P42099

EQUISETACEAE
Equisetum arvense (L.): P41749, P41824
Equisetum hyemale (L.): P40284,
Equisetum laevigata A. Br.: P41825

ONOCLEACEAE
Onoclea sensibilis (L.): P39713

OPHIOGLOSSACEAE
Ophioglossum pusillum Raf.: P41821

OSMUNDACEAE
Osmunda regalis (L.): P39710

THELYPTERIDACEAE
Thelypteris palustris Schott: P39966

MONOCOTS

ALISMATACEAE
Alisma subcordatum Raf.: P39919
Sagittaria latifolia Willd.: P40276

COMMELINACEAE
**Commelina communis* (L.): P40026
Tradescantia ohiensis Raf.: P39874

CYPERACEAE
Bolboschoenus fluviatilis (Torr.) Sojak: P40249
Bulbostylis capillaris (L.) C.B. Clarke: P39890
Carex brachyglossa Mack.: P39733, P41828
Carex buxbaumii Wahlenb.: P41748
Carex conoidea Schk.: P41823
Carex cristatella Britt.: P39926
Carex foenea Willd.: P39440
Carex haydenii Dewey: P39442
Carex longii Mack.: P39734
Carex meadii Dewey: P39438
Carex pellita Willd.: P39723
Carex pensylvanica Lam.: P39420
Carex sartwellii Dewey: P41812
Carex scoparia Schk.: P39725, P41812, P41822
Carex swanii (Fern.) Mack.: P39738
Carex vulpinoidea Michx.: P41830
Cyperus lupulinus (Spreng.) Marcks var. *macilentus* (Fern.) Marcks: P39980
Cyperus strigosus (L.): P39884, P40012
Eleocharis ovata (Roth) Roem. & Schultes: P40275
Eleocharis palustris (L.) Roem. & Schultes: P39724
Eleocharis verrucosa (Svenson) Harms: P39888
Eleocharis wolfii Gray: P39877
Rhynchospora capitellata (Michx.) Vahl.: P42110
Scirpus atrovirens Willd.: P39741
Scirpus cyperinus (L.) Kunth: P39882
Scleria triglomerata Michx.: P40037

IRIDACEAE
Iris shrevei Small: P39709
Sisyrinchium albidum Raf.: P41827

JUNCACEAE
Juncus acuminatus Michx.: P39744
Juncus anthelatus (Wieg.) R. E. Brooks: P41808
Juncus brachycarpus Engelm.: P39878, P40283
Juncus dudleyi Wieg.: P39743
Juncus greenei Oakes & Tuckerm.: P39869
Juncus marginatus Rostk.: P39740
Juncus torreyi Coville: P39923
Luzula bulbosa (A.W. Wood) Smyth: P39434

LEMNACEAE
Lemna minor (L.): P41817

LILIACEAE
Aletris farinosa (L.): P39705
Allium canadense (L.): P41757
Lilium michiganense Farw.: P39746
Polygonatum commutatum (Schult.) A. Dietr.: P40240
Smilacina racemosa (L.) Desf.: P41750

ORCHIDACEAE
Liparis liliifolia (L.) Rich.: P39728
Platanthera flava (L.) Lindl. var. *herbiola* (R.Br.) Luer: P39748
Spiranthes magnicamporum Sheviak: P40229

POACEAE
Agrostis gigantea Roth: P39721

Agrostis hyemalis (Walt.) BSP.: P39732
Agrostis perennans (Walt.) Tuckerm.: P39977
Andropogon gerardii Vitman: P39995
Andropogon virginicus (L.): P42111
Aristida purpurascens Poir.: P39963
**Bromus inermis* Leyss.: P39899
**Bromus tectorum* (L.): P41760
Calamagrostis canadensis (Michx.) P. Beauv.: P39750
Dichanthelium acuminatum (Sw.) Gould and Clark: P39984, P39983
Dichanthelium clandestinum (L.) Gould: P39720
Dichanthelium lindheimeri (Nash) Gould: P39735
Dichanthelium oligosanthes (Schult.) Gould: P39996
**Digitaria sanguinalis* (L.) Scop.: P40023
**Echinochloa crus-galli* (L.) P. Beauv.: P39924, P40034
Elymus riparius Wieg.: P40239, P40271
Eragrostis spectabilis (Pursh) Steud.: P39991
**Festuca arundinacea* Schreb.: P41735
Glyceria striata (Lam.) Hitchc.: P39726
Leersia oryzoides (L.) Swartz: P40230
Leersia virginica Willd.: P42093
Leptoloma cognatum (Schult.) Chase: P39990
Muhlenbergia mexicana (L.) Trin.: P40014, P40272
Muhlenbergia schreberi J.F. Gmel.: P40264
Panicum capillare (L.): P40013
Panicum rigidulum Bosc: P39908
Panicum virgatum (L.): P39905
Paspalum bushii Nash: P40002
Paspalum laeve Michx.: P40010
**Phalaris arundinacea* (L.): P41753
**Phleum pratense* (L.): P41751
**Phragmites australis* (Cav.) Trin.: P40035
**Poa compressa* (L.): P41734, P41811
**Poa pratensis* (L.): P41732
Schizachyrium scoparium (Michx.) Nash: P40287
**Setaria faberi* R.A.W. Herrm.: P40027
Sorghastrum nutans (L.) Nash: P39994
Spartina pectinata Link.: P39881
Sphenopholis intermedia (Rydb.) Rydb.: P39727
Tridens flavus (L.) Hitchc.: P40331
Vulpia octoflora (Walt.) Rydb.: P39928

SMILACACEAE
Smilax tamnoides (L.): P40267

TYPHACEAE
Typha angustifolia (L.): P40248

XYRIDACEAE
Xyris torta Sm.: P39887

DICOTS

ACERACEAE
Acer negundo (L.): P42095
Acer saccharinum (L.): P39417

ANACARDIACEAE
Rhus glabra (L.): P40285
Toxicodendron radicans (L.) Kuntze: P40259

APIACEAE
Cicuata maculata (L.): P39722
**Daucus carota* (L.): P39895
Eryngium yuccifolium Michx.: P39880
Osmorhiza longistylis (Torr.) DC.: P41745
Oxyplois rigidior (L.) Raf.: P40036
Sanicula canadensis (L.): P40022
Thaspium trifoliatum (L.) Gray: P41756

APOCYNACEAE
Apocynum androsaemifolium (L.): P39752
Apocynum sibericum Jacq.: P42103

AQUIFOLIACEAE
Ilex verticillata (L.) Gray: P39912

ASCLEPIADACEAE
Asclepias hirtella (Pennell) Woodson: P39901
Asclepias incarnatum (L.): P41831
Asclepias syriaca (L.): P41829

ASTERACEAE
**Achillea millefolium* (L.): P39898
Ageratina altissima (L.) R.M. King & H. Robins.: P40236
Ambrosia artemisiifolia (L.): P39985
Ambrosia trifida (L.): P40253
Antennaria neglecta Greene: P39864
Antennaria plantaginifolia (L.) Hook.: P39424
Aster ericoides (L.): P40282
Aster fragilis Willd.: P40232 (not in Mohlenbrock 2002)
Aster lanceolatus Willd.: P42098
Aster novae-angliae (L.): P40280
Aster pilosus Willd.: P40279
Aster puniceus (L.): P40273
Bidens cernua (L.): P40277
Bidens frondosa (L.): P40238
Bidens polylepis Blake: P40225
Cirsium discolor (Muhl.) Spreng.: P42102
Cirsium muticum Michx.: P40224
Conyza canadensis (L.) Cronq.: P39992
Coreopsis tripteris (L.): P39998
Erechtites hieracifolia (L.) Raf.: P40030
Erigeron strigosus Muhl.: P39704
Eupatorium altissimum (L.): P40286
Eupatorium perfoliatum (L.): P39970
Eupatorium serotinum Michx.: P40025, P40237
Euthamia gymnospermoides Greene: P40218
Helenium autumnale (L.): P40336
Helianthus mollis Lam.: P40008

Hieracium canadense Michx.: P39982
Hieracium gronovii (L.): P39978
Ionactis linariifolius (L.) Greene: P40330
Krigia biflora (Walt.) Blake: P41755
Krigia virginica (L.) Willd.: P39453
Lactuca canadensis (L.): P40019
Lactuca floridana (L.) Gaertn.: P40024
Liatris aspera Michx.: P39988
Liatris spicata (L.) Willd.: P40001
Oligoneuron riddellii (Frank) Rydb.: P40278
Parthenium integrifolium (L.): P39883
Prenanthes aspera Michx.: P39981
Pseudognaphalium obtusifolium (L.) Hilliard & Burtt.: P40219
Rudbeckia fulgida Ait.: P40228
Rudbeckia subtomentosa Pursh: P40270
Silphium integrifolium Michx.: P40033
Solidago altissima (L.): P40220
Solidago gigantea Ait.: P39967
Solidago missouriensis Nutt.: P39863
Solidago nemoralis Ait.: P39989
Solidago speciosa Nutt.: P40288
**Taraxacum officinale* Weber: P39439
**Tragopogon dubius* Scop.: P41737
Vernonia missourica Raf.: P39964

BETULACEAE
Betula nigra (L.): P39909

BIGNONIACEAE
**Catalpa speciosa* Warder: P41758

BORAGINACEAE
Hackelia virginiana (L.) I.M. Johnston: P40016
Lithospermum croceum Fern.: P39454

BRASSICACEAE
**Alliaria petiolata* (Bierb.) Cavara & Grande: P39436
**Barbarea vulgaris* R. Br.: P39441
Cardamine bulbosa (Muhl.) BSP.: P39416
Cardamine parviflora (L.): P39421
Lepidum virginicum (L.): P41738

CACTACEAE
Opuntia humifusa (Raf.) Raf.: P40000

CAESALPINIACEAE
Chamaecrista fasciculata (Michx.) Greene: P39871

CAMPANULACEAE
Campanula aparinoides Pursh: P39747
Lobelia cardinalis (L.): P40032
Lobelia siphilitica (L.): P39968
Lobelia spicata Lam. var. *spicata*: P40223
Triodanis perfoliata (L.) Nieuwl.: P41809

CAPRIFOLIACEAE
**Lonicera morrowii* Gray: P39451
Sambucus canadensis (L.): P39731

CARYOPHYLLACEAE
**Cerastium fontanum* Baum: P41826
**Holosteum umbellatum* (L.): P39411
Moehringia lateriflora (L.) Fenzl.: P39431
Paronychia canadensis (L.) Wood: P41818
Paronychia fastigiata (Raf.) Fern.: P39745
**Saponaria officinalis* (L.): P40029
Silene antirrhina (L.):P41740
**Silene pratensis* (Spreng.) Godron & Gren.: P39961
Silene stellata (L.) Ait. f.: P39907

CELASTRACEAE
Celastrus scandens (L.): P40269

CHENOPODIACEAE
**Chenopodium album* (L.): P40018
Chenopodium standleyanum Aellen: P40017

CISTACEAE
Helianthemum bicknellii Fern.: P39997
Lechea mucronata Raf.: P40005
Lechea tenuifolia Michx.: P40006

CORNACEAE
Cornus obliqua Raf.: P39718, P40281

CORYLACEAE
Corylus americana Walt.: P40265

CUSCUTACEAE
Cuscuta campestris Yuncker: P40251

DROSERACEAE
Drosera intermedia Hayne: P39892, P40011

ELAEAGNACEAE
**Elaeagnus umbellata* Thunb.: P39452

ERICACEAE
Gaylussacia baccata (Wang.) K. Koch: P39861
Vaccinium angustifolium Ait.: P39426

EUPHORBIACEAE
Acalypha gracilens Gray: P39979
Acalypha rhomboidea Raf.: P39973, P40015
Croton glandulosus (L.): P40003
Euphorbia corollata (L.): P39873

FABACEAE
Apios americana Medic.: P40290
Baptisia alba (L.) Vent.: P39701

Crotalaria sagittalis (L.): P39870
Desmodium sessilifolium (Torr.) Torr. & Gray: P39866
Lathyrus palustris (L.): P39751
Lespedeza capitata Michx.: P39993
**Lespedeza cuneata* (Dum.-Cours.) G. Don: P40221
Lupinus perennis (L.): P39448
**Medicago lupulina* (L.): P41733
**Melilotus albus* Medic.: P39894
Strophostyles leiosperma (Torr. & Gray) Piper: P40009

FAGACEAE
Quercus alba (L.): P39435
Quercus velutina Lam.: P41744

GENTIANACEAE
Bartonia virginica (L.) BSP.: P39737
Gentiana saponaria (L.): P40289

GROSSULARIACEAE
Ribes missouriense Nutt.: P40258

HALORAGIDACEAE
Proserpinaca palustris (L.): P40233

HYPERICACEAE
Hypericum adpressum Barton: P39876, P39906
Hypericum gentianoides (L.) BSP.: P39889
Hypericum majus (Gray) Britt.: P39875, P39891
Hyperiucm mutilum (L.): P39972

LAMIACEAE
Hedeoma hispida Pursh: P39962
**Leonurus cardiaca* (L.): P40021
Lycopus americanus Muhl.: P39927
Lycopus uniflorus Michx.: P39971, P40274
**Mentha arvensis* (L.): P39922
Monarda fistulosa (L.): P39893
Physostegia virginiana (L.) Benth.: P40031
Prunella vulgaris (L.) var. *elongata* Benth.: P39897
Pycnanthemum virginianum (L.) Dur. & B.D. Jacks.: P39879
Scutellaria lateriflora (L.): P39974
Stachys hispida Pursh: P39714
Teucrium canadense (L.): P39885
Sassafras albidum (Nutt.) Nees: P39419
Lythrum alatum Pursh: P39739
Rotala ramosior (L.) Koehne: P39911
Hibiscus moscheutos (L.): P40231
Rhexia virginica (L.): P39868

LAURACEAE
Sassafras albidum (Nutt.) Nees: P39419

LYTHRACEAE
Lythrum alatum Pursh: P39739
Rotala ramosior (L.) Koehne: P39922

MALVACEAE
Hibiscus moscheutos (L.): P40231

MELASTOMACEAE
Rhexia virginica (L.): P39868

MONOTROPACEAE
Monotropa hypopithys (L.): P42094

MORACEAE
Monotropa hypopithys (L.): P42094
**Maclura pomifera* (Raf.) Schneider: P41819
**Morus alba* (L.): P40262

ONAGRACEAE
Circaea lutetiana Aschers & Magnus: P39717
Epilobium coloratum Spreng.: P40260
Gaura biennis (L.): P42100
Ludwigia alternifolia (L.): P39921
Ludwigia palustris (L.) Ell.: P39918
Ludwigia polycarpa Short & Peter: P39920, P40234
Oenothera biennis (L.): P39986
Oenothera clelandii W. Dietr., Raven, & W.L. Wagner: P40007
Oenothera pilosella Raf.: P39925

OXALIDACEAE
Oxalis stricta (L.): P41739
Oxalis violacea (L.): P39433

PHYTOLACCACEAE
Phytolacca americana (L.): P40268

POLEMONIACEAE
Phlox bifida Beck.: P39437
Phlox glaberrima (L.): P39749
Polemonium reptans (L.): P39446

POLYGALACEAE
Polygala cruciata (L.): P39886
Polygala polygama Walt.: P39703, P39960
Polygala sanguinea (L.): P39702

POLYGONACEAE
**Fallopia convolvulus* (L.) A. Love: P40020
Fallopia scandens (L.) Holub: P40261
Persicaria coccinea (Muhl.) Greene: P42107
Persicaria hydropiperoides (Michx.) Small: P40235
Persicaria opelousana (Riddell) Small: P39910
Persicaria pensylvanica (L.) Small: P40250
Persicaria punctata (Ell.) Small: P39987
Polygonum tenue Michx.: P40004
**Rumex acetosella* (L.): P39449
**Rumex crispa* (L.): P41736
Tracaulon sagittatum (L.) Small: P40247

PORTULACACEAE
Claytonia virginica (L.): P39422

PRIMULACEAE
Lysimachia lanceolata Walt.: P39707
Lysimachia quadriflora Sims.: P39917
Lysimachia terrestris (L.) BSP.: P39711

RANUNCULACEAE
Anemone quinquefolia (L.): P39447
Anemone virginiana (L.): P39900
Caltha palustris (L.): P39443
Ranunculus abortivus (L.): P39432

RHAMNACEAE
**Frangula alnus* Mill.: P39719

ROSACEAE
Agrimonia parviflora Sol.: P39965
Aronia melanocarpa (Michx.) Ell.: P39425, P39872
Aronia prunifolia (Marsh.) Rehd.: P39913
Fragaria virginiana Duchesne: P39430
Geum canadense Jacq.: P41742
Geum laciniatum Murr.: P39729
Malus ioensis (Wood) Britt.: P39415
Potentilla arguta Pursh: P41820
Potentilla simplex Michx.: P41747
Prunus serotina Ehrh.: P41746
Prunus virginiana (L.): P39418
Rosa carolina (L.): P42104
**Rosa multiflora* Thunb.: P39730
Rosa palustris Marsh.: P39716
Rubus alleghiensis Porter: P39867
Rubus flagellaris Willd.: P42109
Rubus hispidus (L.): P39708
Rubus occidentalis (L.): P41743
Rubus pensilvanicus Poir.: P39742
Spiraea alba DuRoi: P39903
Spiraea tomentosa (L.): P39865

RUBIACEAE
Cephalanthus occidentalis (L.): P39712
Galium tinctorium (L.): P39736, P41813
Galium trifidum (L.): P39975
Galium triflorum Michx.: P41810

SALICACEAE
Populus deltoids Marsh.: P41741
Populus tremuloides Michx.: P39904
Salix discolor Muhl.: P39412
Salix humilis Marsh.: P39427
Salix interior Rowlee: P42105
Salix nigra Marsh.: P41759

SANTALACEAE
Comandra umbellata (L.) Nutt.: P42101

SAXIFRAGACEAE
Heuchera richardsonii R. Br.: P41754
Penthorum sedoides (L.): P39915
Saxifraga pensylvanica (L.): P41752

SCROPHULARIACEAE
Agalinis tenuifolia (Vahl) Raf.: P40222
Castilleja coccinea (L.) Spreng.: P40217
Chelone glabra (L.): P42114
Gratiola neglecta Torr.: P39715
Mimulus ringens (L.): P39916
Nuttallanthus canadensis (L.) D. Sutton: P39450
Pedicularis canadensis (L.): P39445
Pedicularis lanceolata Michx.: P40227
Penstemon digitalis Nutt.: P39706
Scrophularia lanceolata Pursh: P40028
**Verbascum thapsus* (L.): P39896
Veronicastrum virginicum (L.) Farw.: P39914

SIMAROUBACEAE
**Ailanthus altissima* (Mill.) Swingle: P40266

SOLANACEAE
Solanum carolinense (L.): P40252
**Solanum dulcamara* (L.): P40255

ULMACEAE
Ulmus rubra Muhl.: P40257

URTICACEAE
Boehmeria cylindrica (L.) Sw.: P39976
Parietaria pensylvanica Muhl.: P39862
Pilea pumila (L.) Gray: P40254

VERBENACEAE
Verbena hastata (L.): P39969
Verbena stricta Vent.: P39999

VIOLACEAE
Viola lanceolata (L.): P39429
Viola pedata (L.): P39423
Viola pratincola Greene: P39444
Viola sagittata Ait.: P39428

VITACEAE
Parthenocissus quinquefolia (L.) Planch.: P40256
Vitis riparia Michx.: P40263, P41816

ERIGENIA, Number 25, Spring 2012, pp 36–48

SURVIVAL OF PLANTS ON SLOPED ROOFS WITH TEN CM OF SOIL

Patricia K. Armstrong[1]

ABSTRACT: A total of 100 species of plants were grown on a 47 m^2 (500 ft^2) east facing roof and a 93 m^2 south facing roof at Prairie Sun, Naperville, IL, in 2005. These roofs had a 30° slope and only 10 cm (4 in) of soil. Ninety percent of the species were native prairie and woodland-savanna plants from Illinois or other parts of North America and 10% of the species were from Europe-Asia (mostly *Sedum*). The plants were watered for the first growing season; after that they survived only on rain. In 2008 and 2010 all the plants were relocated and counted, and the percent survival rate calculated for each species present. Seven different classes of survival rates were used ranging from 0 to > 200%. Of the 100 original species, 59 species were successful, 7 additional species can be recommended with some concerns, 24 species were failures, and for another 10 species there were insufficient data to assess their survival rates. Seventy percent of the 10 European-Asian *Sedum* species were highly successful and 65% of the 76 native Illinois species were successful, but 79% of the 14 species native to other parts of USA were unsuccessful and considered failures.

INTRODUCTION

Green roofs (roofs with grass or other vegetation planted on them) have been around since ancient times. Early pioneers in USA frequently used prairie sod for building blocks as well as roofs for their homes on the prairie where there were no trees for building materials. In modern times many European countries, with over 35 years experience in Germany, as well as the United States, have used vegetated green roofs as a means of lowering temperatures in cities with areas of concrete and asphalt (Anonymous, 2003, Kleine 2001, Holtcamp 2001). Green roofs hold and cleanse rainwater and therefore help in storm water management and flood control (Miller 2006). They also add to the insulation value of the building, and they can be attractive and useful areas for people to relax and enjoy nature or to plant vegetable gardens (Phalen 1999, Ulrich 2001). Most green roofs are flat and on tops of large business or industrial buildings with at least 30 cm of soil. Prairie vegetation and even small trees and shrubs have worked very well under these circumstances (Bower 2003).

The purpose of this study was to test if native prairie and woodland vegetation could be successfully grown and maintained in shallow soil. Most green roof specialists recommend using only non-native *Sedum* species under these conditions (Dunnett and Kingsbury 2004, Miller 2002, Snodgrass and Snodgrass 2006, Wisby 2005). Prairie Sun Consultants, Naperville, Illinois, and Foliage Design Systems, Lombard, Illinois, designed a study to determine the feasibility of using native prairie and woodland plants on a sloped roof with only 10 cm of soil. The study occurred at a private single family dwelling in southwest DuPage County about 48 km west of Chicago.

MATERIALS AND METHODS

In May of 2005, 3000 plants were planted on the 30° sloping roof of a home in Naperville, Illinois, in 10 cm of a special light-weight soil mixture (Midwest Trading Intensive Soil Mix, purchased from Midwest Groundcovers in St. Charles, Illinois). Eighty-one different species were planted: 89% native to the Midwest and more western areas of North America and 11% *Sedum* species from Europe and Asia. An additional 20 species grew as volunteers; 19 were Illinois native plants, and one was a weedy *Sedum* native to Eurasia. Fifty species (1000 plants) were planted on the east roof and 69 species (2000 plants) were planted on the south roof. A total of 20 species volunteered on the east roof and 13 species volunteered on the south roof, making a total of 101 species in the study. Fifty-two species occurred on both roofs (Figures 1–4).

The more-shaded east roof received morning sun and had overhanging trees and the upper-story of the house which created a cooler, damper environment than the larger full-sun, south roof. Species selected for the east roof included some woodland species adapted

[1] Prairie Sun Consultants, 612 Staunton Road, Naperville, IL 60565.

Figure 1. East roof (May 4, 2008) showing *Cercis canadensis, P. reptans, B. dactyloides, C. rosea, H. richardsonii, A. canadensis* and *Sedum ternatum.*

to more shade and moisture. Plants selected for the south roof were plants mostly adapted to well-drained prairie, sand or low-soil glade habitats. The planting methods, first year maintenance and first year survival were reported previously in (Armstrong 2006, Armstrong 2009, and Ulrich 2008).

It took five days to plant the two roofs. Most (58 species) of the plants were 5 to 8 cm plugs, some (13 species) were tiny, delicate 2 to 3 cm seedlings, and a few (8 species) were dormant roots. Three large plants (8 to 15 cm) and three species of smaller plug-sized plants were transplanted. Plants were purchased from 10 different nurseries seven of which were located within 161 km of Naperville; three nurseries were located in Minnesota, Nebraska and Maryland. Planting was finished by June of 2005 with placement according to an artistic design featuring waves of different species and clustered groupings. During the first growing season the plants were watered every day for the first week and once a week until September. The first watering included a weak solution of growth stimulator. No fertilizer was used. Most weeds present in the plugs were removed by hand the first year along with some aggressively-spreading plants. Additional weeding was continued annually. No water was

Figure 2. East roof (October 5, 2008) showing *A. oblongifolius, A. ericoides, S. speciosa, A. scoparius, P. purpureum* and *H. richardsonii.*

Figure 3. South roof, west edge (May 15, 2006) showing *Coryphantha vivipara, P. bifida, Phlox pilosa* var. *fulgida, S. floriferum, S. pulchellum* and *L. perenne* var. *lewisii.*

provided during the second through fifth growing seasons in spite of the usual July and August droughts common in the Chicago area. In November of 2005, plants were trimmed at 15 cm and the material left on the roof as mulch during the winter. In March of 2006 all plants were cut back to a height of 5 to 10 cm and the dead material removed from the roof. During the second through fifth years, the plants were left standing all winter and cut back to 5 to 10 cm in March and the dead thatch removed.

Since the original planting was accomplished according to a detailed plan showing the number of each species and their exact location, it was possible to search for the surviving plants during the third and fifth growing seasons (March to September of 2008 and 2010). All species from the original planting were located, counted and compared with the planting plan to determine the percent survival rate for each species present. If 10 plants were planted and 10 plants were found that is a survival rate of 100%; 5 plants counted would be a survival rate of 50%, 20 plants counted would be a survival rate of 200%, and 750 plants counted would be a survival rate of 7500%. When it was difficult to discern individual plants, measurements of area covered were used. Locations were mapped in red to show the gains and losses in area covered and number of individual plants counted.

All of the original species survived their first year and 65% of them also flowered that year. About 10% of the species did not survive to the second year (Armstrong 2006, Armstrong 2009). Third- and fifth-year survival rates of the plant species were divided into six different classes: (1) volunteer plants that were not planted (count of plants present); (2) plants with a 100% or higher survival rate (these were considered highly successful and suffered no losses so that their third and fifth year counts were ≥ than the number of plants that were planted; (3) plants with a 75 to 99% survival rate were also considered successful plants; (4) plants with a 50 to 74% survival rate were plants that could succeed with added care; (5) plants with a 25 to 49% survival rate were plants that could not succeed

Figure 4. South roof, (August 31, 2006) showing *L aspera, A. ericoides, S. nemoralis, A. scoparius, B. gracilis, K. cristata, E. altissimum* and *V. stricta.*

without added care; (6) plants with a 1 to 24% survival rate were considered unsuccessful in this study; and (7) plants with a 0% survival rate were plants that did not survive past the second year.

RESULTS AND DISCUSSION

Twenty-six species came in as volunteers, 20 on the east roof and 13 on the south roof (Table 1). Twenty of these were new species to the study bringing the total number of species studied to 101 (nomenclature follows Swink & Wilhelm 1994, except for a few non-native nursery plants). Of the 10 high quality prairie species 3 came from seeds blown up from the surrounding yard which is totally landscaped with native plants, 5 came in with the plugs as there was no local source for their seeds, and 2 came from seed blown down onto the east roof from plants on the south roof. Five of the high quality prairie plants died before the fifth year, but the other five (*Aster oblongifolius, Aster sericeus, Bouteloua curtipendula, Carex bicknellii,* and *Penstemon hirsutus*) have established themselves and are increasing in numbers. Five of the six lower quality prairie plants (*Aster novae-angliae, Rudbeckia hirta, Solidago nemoralis, Solidago rigida,* and *Tradescantia ohiensis*) came from the yard while only *Verbena stricta* came from seed blown off the south roof. *R. hirta* was not present in 2005, *S. rigida* is spreading rapidly. The other four species and the western prairie species, *Linum perenne* var. *lewisii,* are spreading slowly.

Seeds of the eight aggressive weedy species came mostly from the yard (five species) with three species (*Epilobium ciliatum, Oxalis stricta,* and *Sedum sarmentosum*) coming

Table 1: Survival of volunteer roof plants at Prairie Sun.

Latin Name	Common Name	Roof Exposure	Where Native	Plant Source	Plant Ecology	Number Planted	Number Year 3	Observed Year 5
Acalypha rhomboidea	three-seeded mercury	East	Illinois	Seed from yard	Weedy shade*	0	10	>35
Aster laevis	Smooth blue aster	East	Illinois	Seed from yard	HQ mesic prairie	0	1	0
Aster novae-angliae	New England aster	East	Illinois	Seed from yard	Wet-mesic prairie	0	3	5
Aster novae-angliae	New England aster	South	Illinois	Seed from yard	Wet-mesic prairie	0	3	0
Aster oblongifolius	Aromatic aster	East	Illinois	Seed from yard	HQ LS hill prairie	0	1	43
Aster ptarmicoides	Stiff aster	South	Illinois	Seed in plug	HQ LS hill prairie	0	1	0
Aster sagitifolius var. *drummondii*	Drummond's aster	East	Illinois	Seed from yard	Weedy fields, prairies, woods**	0	>25	>100
Aster sagitifolius var. *drummondii*	Drummond's aster	South	Illinois	Seed from yard	Weedy fields, prairies, woods**	0	>25	>100
Aster sericeus	Silky aster	East	Illinois	Seed from south roof	HQ dry hill prairie	0	1	2
Bouteloua curtipendula	Side-oats grama	South	Illinois	Seed in plug	HQ hill prairie	0	1	16
Carex bicknellii	Bicknell's sedge	East	Illinois	Seed from yard or south roof	HQ dry prairie	0	1	3
Epilobium ciliatum	Northern willowherb	East	Illinois	Seed in plug	weedy fields, marshes*	0	8	>50
Epilobium ciliatum	Northern willowherb	South	Illinois	Seed in plug	weedy fields, marshes*	0	3	>50
Erigeron annuus	Annual fleabane	East	Illinois	Seed from yard	weedy fields, prairies**	0	5	>25
Erigeron annuus	Annual fleabane	South	Illinois	Seed from yard	weedy fields, prairies**	0	>25	>100
Eupatorium altissimum	Tall boneset	East	Illinois	Seed from yard	weedy fields, prairies	0	1	5
Eupatorium rugosum	White snakeroot	East	Illinois	Seed from yard	weedy fields, prairies**	0	1	3
Helianthus annuus	Annual Sunflower	East	Illinois	Birdfeeder seed	Roadsides, fields	0	1	0
Helianthus annuus	Annual sunflower	South	Illinois	Birdfeeder seed	Roadsides, fields	0	2	0
Krigia biflora	Cythia	South	Illinois	Seed in plug	HQ prairies, savannas	0	1	0
Liatris pycnostachya	Prairie blazing star	South	Illinois	Seed in plug	HQ prairies	0	1	0
Linum perenne var. *lewisii*	Wild blue flax	East	USA	Seed from south roof	Western prairies	0	2	6
Oxalis stricta	Common wood sorrel	East	Illinois	Seed in plug	weedy lawns, shady areas**	0	>100	>150
Oxalis stricta	Common wood sorrel	South	Illinois	Seed in plug	weedy lawns, shady areas**	0	>50	>75
Penstemon hirsutus	Hairy beard tongue	East	Illinois	Seed from yard or south roof	HQ hill prairies	0	1	2
Rudbeckia hirta	Black-eyed Susan	East	Illinois	Seed from yard	LQ prairies, savannas	0	1	0
Sedum sarmentosum	Creeping stonecrop	South	Eurasia	Seed in plug	Weedy gardens*	0	1	5

Table 1: Continued

Latin Name	Common Name	Roof Exposure	Where Native	Plant Source	Plant Ecology	Number Planted	Number Year 3	Observed Year 5
Solidago nemoralis	Old field goldenrod	East	Illinois	Seed from yard	Dry prairies, fields	0	3	3
Solidago rigida	Stiff goldenrod	East	Illinois	Seed from yard	Dry-mesic prairies*	0	1	5
Solidago rigida	Stiff goldenrod	South	Illinois	Seed from yard	Dry-mesic prairies*	0	1	3
Talinum rugospermum	Prairie fame flower	South	Illinois	Seed in plug	HQ sand prairies	0	1	0
Tradescantia ohiensis	Ohio spiderwort	East	Illinois	Seed from yard	Prairies, savannas	0	2	2
Verbena stricta	Hoary vervain	East	Illinois	Seed from south roof	LQ gravel areas, prairies	0	2	5

*= aggressive, may need control in future
**= very aggressive, needs control
HQ = high quality
LQ = low quality
LS = limestone

in with the plugs. *O. stricta* is the most aggressive of the three. *Acalypha rhomboidea, Aster sagitifolius* var. *drummondii, Erigeron annuus, Eupatorium altissimum,* and *E. rugosum* are the most aggressive plants on the roof and require frequent weeding. Of the 20 new species added as volunteers, 12 have successfully established themselves and 8 have failed to survive. Survival rates for some plants on the east roof (Table 2), south roof (Table 3) and overall survival (Table 4) were similar while other plants did much better on one roof or the other making it difficult to decide if these species were successes or failures. Of the 81 species planted in the study, the plants native to Illinois had the highest success rate (60%) and were followed by the Eurasian species with a 56% success rate. Plants native to other parts of USA survived the worst with a 29% success rate.

Most of the species evaluated fell easily into either successful or unsuccessful categories with about 12 species with mixed survival rates falling in between. Seven of these more perplexing species had extremely variable survival rates from year to year: *Anemone caroliniana, Blephilia ciliata, Monarda punctata, Sedum pulchellum, Talinum calycina, Tradescantia ohiensis* and *T. virginiana. Sedum* and *Talinum* are both annuals and *A. caroliniana, B. ciliata* and *M. punctata* are short lived perennials so that their times of seeding make them appear to be very successful or complete failures depending on where the count year falls in their life cycle. The two *Tradescantia* species were completely gone one year and then found the next year. Other species in this mixed group performed well on one roof and poorly on the other or fell into two different categories of survival rates.

In evaluating the nurseries and where the plants came from, all nursery stock was healthy and grew well the first year, so there seemed to be little difference in the survival rates based on the providing nursery. Plants native to Illinois and *Achillea* and *Sedum* species from Eurasia did well. Plants native to other parts of the USA were largely failures.

Plants that were transplanted at 10–15 cm in size all failed during their first year. Plugs (5–8 cm) were the most successful along with smaller transplants the size of the plugs (62% survival rate). Dormant roots did not do as well (~50% successful) the same as small seedlings (1–2 cm) which were slower to establish and more sensitive to crowding and drought conditions. Although no species were planted as seeds, seeds were produced by the plants on the roof and in the yard and these were very successful in increasing the survival rate of the most aggressive plants.

CONCLUSIONS

The following 48 species had survival rates of 100% or more and are highly recommended for use on green

Table 2: Plants Planted on the East Roof at Prairie Sun.

Latin Name	Common Name	Where Native	Type Planted	PlantEcology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Anemone canadensis	Meadow anemone	Illinois	Dormant root	LQ prairies, fields	6	0	0
Aquilegia canadensis	Wild columbine	Illinois	Plugs	HQ savanna, woods, rocky areas	16	113	144
Aster macrophyllus	Big-leaved aster	Illinois	Dormant root	HQ hilly woods	15	27	47
Carex rosea	Curly-styled wood sedge	Illinois	Plugs	Woods	28	71	25
Corydalis aurea	Golden corydalis	Illinois	Plugs	Woods	14	100	93
Polemonium reptans	Jacob's ladder	Illinois	Plugs	Woods*	22	368	500
Sedum tatarowinii	Mongolian stardust	Eurasia	Plugs	Garden plant	28	18	14
Sedum ternatum	Three-leaved stonecrop	Illinois	Plugs	HQ woods, canyons	35	129	89
Solidago speciosa	Showy goldenrod	Illinois	Plugs	HQ sand prairies, savannas*	15	167	553
Viola sororia	Common blue violet	Illinois	Small transplants	LQ woods, lawns**	10	260	500
Viola striata	Cream violet	Illinois	Small transplants	HQ woods	1	0	0

*= aggressive, may need control in future
**= very aggressive, needs control
LQ = low quality
HQ = high quality
LS = limestone

roofs with only 10 cm of soil: *Acalypha rhomboidea, Achillea millefolium, Allium stellatum, Andropogon scoparius, Anemone caroliniana, Antennaria rosea, Aquilegia canadensis, Artemesia ludoviciana, Asclepias verticillata, Aster ericoides, A. novae-angliae, A. oblongifolius, A. sagitifolius* var. *drummondi, A. sericeus, Bouteloua curtipendula, Buchloe dactyloides, Carex bicknelli, Carex pensylvanica, Coreopsis lanceolata, Epilopium ciliatum, Erigeron annuus, Eupatorium altissimum, E. rugosum, Geun triflorum, Heuchera richardsonii, Koeleria cristata, Liatris aspera, Linum perenne* var. *lewisii, Opuntia humifusa, Oxalis stricta, Penstemon hirsutus, Petalostemum purpureum, Phlox bifida, Polemonium reptans, Sedum acre, Sedum album, Sedum floriferum, Sedum kamtschaticum, Sedum pulchellum, S. sarmentosum, Sedum spurium, Solidago nemoralis, S. rigida, Solidago speciosa, Sporobolus heterolepis, Talinum calycina, Viola stricta* and *V. sororia.*

Although the following 11 species did not have 100% survival rates, they lost less than 25% of their individuals and can be recommended for growing on green roofs with only 10 cm of soil: *Amorpha canescens, Bouteloua gracilis, Bouteloua hirsuta, Corydalis aurea, Coryphantha vivipara, Eragrostis spectabilis, Ruellia humulis, Sedum ternatum, Solidago sciaphila, Tradescantia ohiensis* and *T. virginiana.*

Of the 59 species that were the most successful, 83% were Illinois natives, 12% were Eurasian species and only 5% were native to other parts of USA. Some of the reasons these species were successful are: (1) most are native to Illinois and thus adapted to the climate; (2) many are aggressive, weedy species known to invade different habitats(i.e. *Acalpha rhomboidea, Artemesia ludoviciana, Aster sagitifolius* var. *drummondii, Erigeron annuus, Eupatorium altissimum, E. rugosum* and *O. stricta*; (3) the Eurasian *Sedum* species are small and adapted to shallow soil; (4) some plants are characterized as ephemeral (i.e. *Anemone caroliniana, A. patens* var. *wolfgangiana*, *Koeleria cristata,* and *Phlox bifida*); (5) plants able to go dormant during droughts and resume growth when fall rains return (i.e. *Petalostemon purpureum* and *Sporobolus heterolepis*); (6) plants with fibrous root systems such as grasses and sedges grow easier in shallow soil; (7) plants with large storage roots functioning to survive droughts (i.e. *Allium, Liatris* or *Psoralea*); (8) plants with narrow, grass-like leaves (grasses and sedges) or tiny, dissected leaves (i.e. *Amorpha canescens, Aster sericeus, Linum perenne* var. *lewisii* or *Petalostemum purpureum*) which transpire less water in dry weather; (9) plants with a dense, tussock-like growth forms such as many grasses and *Sedum* species also conserve water; (10) plants with succulent, water-storing leaves (i.e. *Allium, Sedum, Talinum* or the cacti *Coryphantha* and *Opuntia* are known to survive extended droughts; and (11) many of the most successful species were planted as

Table 3: Survival rates for plants on the south roof at Prairie Sun.

Latin Name	Common Name	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Achillea millefolium	Yarrow, milfoil	Europe	Plugs	Dry fields, prairies*	12	50	258
Anemone caroliniana	Carolina anemone	Illinois	Dormant roots	HQ hill prairies	9	67	767
Artemesia ludoviciana	White sage	Illinois	Seedlings	LQ sand prairie, railroad edges**	32	>200	1219
Aster sericeus	Silky aster	Illinois	Plugs	HQ dry hill prairies	15	220	420
Blephilia ciliata	Ohio horse mint	Illinois	Plugs	HQ prairies, LS glades	8	25	0
Callirhoe triangulata	Clustered poppy mallow	Illinois	Seedlings	HQ sand prairies, savannas	2	0	0
Carex bicknellii	Bicknell's sedge	Illinois	Plugs	HQ dry prairies	36	92	347
Chrysopsis camporum	Golden aster	Illinois	Large plant	Sand prairies	1	0	0
Coreopsis grandiflora	Large-flowering coreopsis	USA	Plugs	Western prairies	17	0	0
Gaillardia pulchella	Blanket flower	USA	Plugs	Western prairies	25	0	0
Lewisia cotyledon	Siskiyou lewisia	USA	Plugs	Western prairies	32	0	0
Liatris punctata var. *nebraskana*	Dotted blazing star	USA	Plugs	Western prairies	7	86	29
Linum perenne var. *lewisii*	Blue flax	USA	Plugs	Western prairies	32	138	313
Monarda punctata	Dotted horse mint	Illinois	Seedlings	Sand prairies, savannas	18	422	6
Penstemon hirsutus	Hairy beard tongue	Illinois	Plugs	HQ gravel prairie	28	100	582
Phlox bifida	Cleft phlox	Illinois	Plugs	HQ sand savanna	32	103	406
Phlox pilosa var. fulgida	Prairie phlox	Illinois	Plugs	HQ prairie	27	22	4
Psoralea esculenta	Prairie turnip	USA	Dormant roots	HQ hill prairies	5	60	20
Ratibida columnifera	Long-headed coneflower	USA	Plugs	Western prairies	24	4	0
Sedum acre	Wall pepper	Eurasia	Plugs	Fields, cemeteries*	64	23	111
Sedum album	White stonecrop	Eurasia	Seedlings, Plugs	Fields, cemeteries	34	115	142
Sedum floriferum	Bailey's gold stonecrop	Eurasia	Plugs	Meadows**	32	>200	>300
Sedum lanceolatum	Lance-leaf stonecrop	USA	Seedlings	Western prairies, montane areas	32	0	0
Sedum pulchellum	Widow's cross	Illinois	Plugs	Rocky glades	32	84	954
Sedum stenopetalum	Wormleaf stonecrop	USA	Seedlings	Western prairies, montane areas	36	6	8
Sempervivella alba	Himalayian stonecrop	Asia	Plugs	Montane areas	23	0	0
Sisyrinchium campestre	Prairie blue-eyed grass	Illinois	Dormant roots	HQ dry prairies	20	0	0

Table 3: Continued

Latin Name	Common Name	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Solidago nemoralis	Old field goldenrod	Illinois	Plugs	Fields, prairies	18	44	217
Solidago sciaphila	Shadowy goldenrod	Illinois	Transplants	LS glades, canyons	2	50	50
Tradescantia ohiensis	Ohio spiderwort	Illinois	Transplants	Prairies, savannas	5	0	0
Tradescantia virginiana	Virginia spiderwort	Illinois	Plugs	Oak woods, sand prairies	12	0	67
Verbena stricta	Hoary vervain	Illinois	Plugs	LS gravel, prairies*	14	3571	479

*= aggressive, may need control in future
**= very aggressive, needs control
HQ = high quality
LQ = low quality
LS = limestone

plugs which seemed to be the type of plants with the highest survival rates.

The following 7 species were somewhat less successful, but have many of the same adaptive characteristics. They are also recommended for use on green roofs with only 10 cm of soil but only if they are given extra water during times of drought and special attention is given to placing them where no taller or more aggressive plants can shade or crowd them. These recommended-with-reservation species are: *Anemone patens* var. *wolfgangiana, Aster macrophyllus, Carex rosea, Liatris cylindracea, L. punctata* var. *nebraskana, Psoralea esculenta* and *Sedum spectabile.* The biggest problem with all *Liatris* species is their food-storing corms. Raccoons and squirrels were observed to dig and eat the roots of these plants. It appeared that small mammal predation was more of a factor in their lower survival rates than their adaptability to shallow soil. The *Psoralea* and *Anemone* also incurred some mammal predation. The *Aster* and *Carex* both had problems competing with the many larger, more aggressive species on the east roof.

The following 8 species persisted for the five years of the study but their survival rates decreased or were < 25%: *Asclepias tuberosa, Echinacea angustifolia, Echinacea pallida, Euphorbia corollata, Penstemon caespitosum, Phlox pilosa* var. f*ulgida, Sedum stenopetalum* and *Sedum tatarowinii.* These plants cannot be recommended for use on green roofs with only 10 cm of soil.

There were 34 species that failed to succeed. Reasons for failure include: (1) small mammal predation (i.e. *Coryphantha vivipara, Liatris aspera, L. cylindracea, L. punctata* var. *nebraskana* and probably on *Psoralea esculenta*); (2) some annual species need bare areas for their seeds (i.e. *Sedum pulchellum, Talinum sp., Anemone caroliniana, Blephilia ciliata* and *Monarda punctata*); (3) many of the species from other parts of the USA were not hardy in the Chicago climate; (4) plants with deep or running taproots (i.e. *Asclepias tuberosa,* the *Echinacea* species and *Euphorbia corollata*) were not successful; (5) competition from tall, aggressive species adversely impacted some plants (i.e. *Atennaria rosea, Aster macrophyllus, Bouteloua hirsuta, Carex rosea* and some *Sedum* sp); and (6) plants with large leaves transpired more water (i.e. *A. macrophyllus* and *Heuchera richardsonii*).

These 34 species can be considered failures and not suited for use on a green roof with only 10 cm of soil. Data was insufficient to calculate a survival rate for 10 species: *Aster laevis, A. ptarmicoides, Callirhoe triangulata, Chrysopsis camporum, Krigia biflora, Liatris pycnostachya, Rudbeckia hirta, Solidago sciaphila, Talinum rugospermum* and *Viola striata* because only one or two individuals were planted.

Table 4: Survival rates for plants on both roofs at Prairie Sun.

Latin Name	Common Name	Roof Exposure	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Allium stellatum	Prairie onion	East	Illinois	Dormant roots	HQ hill prairies	7	86	100
Allium stellatum	Prairie onion	South	Illinois	Dormant roots	HQ hill prairies	22	123	441
Amorpha canescens	Lead plant	East	Illinois	Seedlings	HQ dry-mesic prairies	7	43	57
Amorpha canescens	Lead plant	South	Illinois	Seedlings	HQ dry-mesic prairies	21	48	71
Andropogon scoparius	Little bluestem	East	Illinois	Plugs	Sand prairies, savanna	30	163	187
Andropogon scoparius	Little bluestem	South	Illinois	Plugs	Sand prairie, savannas	39	131	118
Anemone patens var. *wolfgangiana*	Pasque flower	East	Illinois	Plugs	HQ hill prairies, sand savannas	10	70	54
Anemone patens var. *wolfgangiana*	Pasque flower	South	Illinois	Plugs	HQ hill prairies, sand savanna	22	36	45
Antennaria rosea	Pink pussy toes	East	USA	Plugs	Western prairies, montane areas	16	160	127
Antennaria rosea	Pink pussy toes	South	USA	Plugs	Western prairies, montane areas	17	18	12
Asclepias tuberosa	Butterfly milkweed	East	Illinois	Seedlings	HQ prairies, savanna, sand	11	36	18
Asclepias tuberosa	Butterfly milkweed	South	Illinois	Seedlings	HQ prairies, sand savannas	17	18	6
Asclepias verticillata	Whorled milkweed	East	Illinois	Seedlings	LQ dry prairies, fields**	11	1546	1000
Asclepias verticillata	Whorled milkweed	South	Illinois	Seedlings	LQ dry prairies, fields**	8	3125	1175
Aster ericoides	Heath aster	East	Illinois	Plugs	Hills, dry prairies**	3	2267	3133
Aster ericoides	Heath aster	South	Illinois	Plugs	Hills, dry prairies**	23	544	752
Bouteloua gracilis	Blue grama	East	Illinois	Plugs	Western dry prairies	20	80	80
Bouteloua gracilis	Blue grama	South	Illinois	Plugs, seedlings	Western dry prairies	49	86	94
Bouteloua hirsuta	Hairy grama	East	Illinois	Seedlings	Western dry prairies	31	23	13
Bouteloua hirsuta	Hairy grama	South	Illinois	Seedlings	Western dry prairies	45	38	71
Buchloe dactyloides	Buffalo grass	East	USA	Plugs	Western dry prairies	27	148	111
Buchloe dactyloides	Buffalo grass	South	USA	Plugs	Western dry prairies	48	79	123
Callirhoe involucrata	Purple poppy mallow	East	Illinois	Plugs	Western dry prairies	5	20	0
Callirhoe involucrata	Purple poppy mallow	South	Illinois	Plugs, one large plant	Western dry prairies	27	0	0
Carex pensylvanica	Common oak sedge	East	Illinois	Seedlings, plugs	Savannas, oak woods	29	66	169

Table 4: Continued

Latin Name	Common Name	Roof Exposure	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Carex pensylvanica	Common oak sedge	South	Illinois	Seedlings, plugs	Savannas, oak woods	62	173	180
Coreopsis lanceolata	Sand coreopsis	East	Illinois	Plugs	Sand prairies	4	50	n
Coreopsis lanceolata	Sand coreopsis	South	Illinois	Plugs	Sand prairies	28	136	n
Coryphantha vivipara	Spinystar cactus	East	USA	Plugs	Western dry prairies	3	33	0
Coryphantha vivipara	Spinystar cactus	South	USA	Plugs	Western dry prairies	29	90	72
Echinacea angustifolia	Black Sampson	East	USA	Plugs	Western prairies	14	14	0
Echinacea angustifolia	Black Sampson	South	USA	Plugs	Western prairies	18	22	11
Echinacea pallida	Pale purple coneflower	East	Illinois	Plugs	HQ dry prairie	15	7	20
Echinacea pallida	Pale purple coneflower	South	Illinois	Plugs	HQ dry prairie	19	5	0
Eragrostis spectabilis	Purple love grass	East	Illinois	Plugs	Sand savannas, railroad edges	32	3	0
Eragrostis spectabilis	Purple love grass	South	Illinois	Plugs	Sand savannas, railroad edges	24	63	79
Euphorbia corollata	Flowering spurge	East	Illinois	Seedlings	LQ dry prairies, fields	7	43	14
Euphorbia corollata	Flowering spurge	South	Illinois	Seedlings	LQ dry prairie, fields	25	52	24
Geum triflorum	Prairie smoke	East	Illinois	Plugs	HQ dry prairie	9	100	111
Geum triflorum	Prairie smoke	South	Illinois	Plugs	HQ dry prairie	23	252	357
Heuchera richardsonii	Prairie alum root	East	Illinois	Plugs	HQ prairies, woods	10	100	220
Heuchera richardsonii	Prairie alum root	South	Illinois	Plugs	HQ prairies, woods	10	60	60
Hymenoxys grandiflora	Old-man-of-the-mountains	East	USA	Plugs	Colorado alpine areas	3	0	0
Hymenoxys grandiflora	Old-man-of-the-mountains	South	USA	Plugs	Colorado alpine areas	17	0	0
Koeleria cristata	June grass	East	Illinois	Plugs	HQ prairies, savanna	14	71	436
Koeleria cristata	June grass	South	Illinois	Plugs	HQ prairies, savanna	49	78	245
Liatris aspera	Rough blazing star	East	Illinois	Plugs	Dry prairies, savannas	5	120	100
Liatris aspera	Rough blazing star	South	Illinois	Plugs	Dry prairies, savannas	33	97	53
Liatris cylindracea	Cylindrical blazing star	East	Illinois	Plugs	Dry prairies	9	67	22
Liatris cylindracea	Cylindrical blazing star	South	Illinois	Plugs	Dry prairies	24	50	20

Table 4: Continued

Latin Name	Common Name	Roof Exposure	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Lupinus perennis var. *occidentalis*	Wild lupine	East	Illinois	Plugs	Sand prairies, savannas	5	0	0
Lupinus perennis var. *occidentalis*	Wild lupine	South	Illinois	Plugs, one large plant	Sand prairies, savannas	27	0	0
Oenothera macrocarpa	Bigfruit evening primrose	East	Illinois	Plugs	Prairies, glades	6	0	0
Oenothera macrocarpa	Bigfruit evening primrose	South	Illinois	Plugs	Prairies, glades	21	0	0
Opuntia humifusa	Eastern prickly pear	East	Illinois	Plugs	Sand prairies, savannas	1	>100	>420
Opuntia humifusa	Eastern prickly pear	South	Illinois	Plugs	Sand prairies, savannas	11	120	520
Penstemon caespitosus	Mat penstemon	East	USA	Plugs	Western prairies	10	0	0
Penstemon caespitosus	Mat penstemon	South	USA	Plugs	Western prairies	22	27	9
Petalostemon purpureum	Purple prairie clover	East	Illinois	Plugs	HQ dry-mesic prairies	13	85	223
Petalostemum purpureum	Purple prairie clover	South	Illinois	Plugs	HQ dry-mesic prairies	19	63	100
Rudbeckia speciosa var. *sullivantii*	Showy black-eyed Susan	East	Illinois	Plugs	HQ wet LS prairies	4	0	0
Rudbeckia speciosa var. *sullivantii*	Showy black-eyed Susan	South	Illinois	Plugs	HQ wet LS prairies	14	0	0
Ruellia humilis	Wild petunia	East	Illinois	Dormant roots	HQ dry prairies	20	65	85
Ruellia humilis	Wild petunia	South	Illinois	Dormant roots	HQ dry prairies	12	75	67
Sedum kamtschaticum	Russian stonecrop	East	Eurasia	Plugs	Meadows**	6	>100	>250
Sedum kamtschaticum	Russian stonecrop	South	Eurasia	Plugs	Meadows**	18	133	278
Sedum spectabile	Showy stonecrop	East	Eurasia	Plugs	Meadows	29	24	14
Sedum spectabile	Showy stonecrop	South	Eurasia	Plugs	Meadows	3	33	33
Sedum spurium	Dragon's blood	East	Eurasia	Seedlings, plugs	Meadows*	27	100	115
Sedum spurium	Dragon's blood	South	Eurasia	Seedlings, plugs	Meadows*	57	144	212
Sporobolus heterolepis	Prairie dropseed	East	Illinois	Plugs	HQ mesic prairies	13	62	77
Sporobolus heterolepis	Prairie dropseed	South	Illinois	Plugs	HQ mesic prairies	20	75	105
Talinum calycina	Showy fameflower	East	Illinois	Seedlings, plugs	HQ sandy areas	20	40	50
Talinum calycina	Showy fameflower	South	Illinois	Seedlings, plugs	HQ sandy areas	15	27	297

Table 4: Continued

Latin Name	Common Name	Roof Exposure	Where Native	Type Planted	Plant Ecology	Number Planted	Percent Survival Year 3	Percent Survival Year 5
Viola pedata var. *lineariloba*	Birdfoot violet	East	Illinois	Dormant roots	HQ sandy prairies, savannas	2	0	0
Viola pedata var. *lineariloba*	Birdfoot violet	South	Illinois	Dormant roots	HQ sandy prairies, savannas	8	0	0

*= aggressive, may need control in future
**= very aggressive, needs control
HQ = high quality
LQ = low quality
n = no year 5 data yet

LITERATURE CITED

Anonymous 2003. A guide to rooftop gardening. Chicago Department of Environment.

Armstrong, P. K. 2006. Feasibility of using prairie plants on a sloped roof with 4 in. of soil. pp. 209–216 *in* Proceedings of the Twentieth North American Prairie Conference. University of Nebraska at Kearney.

Armstrong, P. K. 2009. Feasibility of using prairie plants on a sloped roof with 4 in. of soil. Erigenia 11:3–8.

Bower, J. 2003. The tallest tall grass prairie. Audubon, 105(3):18 pp.

Dunnett, N. and N. Kingsbury. 2004. Planting green roofs and living walls. Timber Press, Portland, Oregon. 254 pp.

Holtcamp, W. 2001. A grass-roofs effort. Sierra, 86(3):24–27.

Kleine, A. 2001. Rooftop garden cools windy city. The American Gardener, 80(4):59 pp.

Miller, C. 2002. Updating the sod roof. Landscape Architecture, 92(11):59 pp.

Miller, M. 2006. Not a sprinkler in sight. Chicagoland Gardening, XII(1):48–53.

Phalen, T. 1999. Updated roof tops. The American Gardener, 78(5):10–15.

Snodgrass, E. C. and L. L. Snodgrass. 2006. Green roof plants: A resource and planting guide. Timber Press, Portland, Oregon. 204 pp.

Swink, F. and G. Wilhelm. 1994. Plants of the Chicago region. 4th Ed. Indiana Academy of Science, Indianapolis, Indiana. 921 pp.

Ulrich, C. 2001. Sky high roof gardening in Chicago. Chicagoland Gardening, VII(2):51–57.

Ulrich, C. 2008. Up on the roof. Chicagoland Gardening, XIV(4):46–51.

Wisby, G. 2005. Home's green roof has a slant to it. Chicago Sun Times. April 28, 2005, Metro Section, 20 pp.

ERIGENIA, Number 25, Spring 2012, pp 49–54

THE ORIGIN AND MAINTENANCE OF MIDWESTERN HILL PRAIRIES

Paul D. Kilburn[1]

ABSTRACT: Hill prairie communities, often less than one hectare in area, occur on south-facing slopes overlooking major rivers in the Midwest. Their rapid invasion today by surrounding forest leads directly to two questions. First, how did they originate? And second, how have they been maintained since their origin? Several lines of evidence strongly suggest that these hill prairies originated when prairies became the dominant vegetation of the Midwest. They were maintained as open prairies by frequent fires set by Native Americans. These fires were set to keep the surrounding forested areas open, and spread to and through the hill prairies, thus setting back or killing invading woody plants, and maintaining the dominance of native grasses and forbs.

INTRODUCTION

Hill prairies, also termed dry prairies or loess hills, form a small picturesque grassland community along the bluffs and hills overlooking major river valleys in Midwestern states (Figure 1) (Braun 1950, Evers 1955). They dominate on a variety of soil substrates including loess, sand, gravel and glacial drift (Schwartz et al. 1997). These botanical gems, often less than a hectare in area, and rarely over five hectares, occur mainly on south and west-facing slopes of hills that have more insolation and provide hotter and drier conditions than the uplands behind. Because of the scenic views from these high points, as well as their unique composition of native forbs and grasses, they have long attracted human interest. This interest includes people today, as well as Native Americans who formerly occupied this area.

Locations of the hill prairies along the Missouri River in Iowa and western Missouri cover a wider band up to 10 miles wide in places (Novacek et al. 1985, Mutel 1989). The portion in Missouri occurs in northwestern Missouri where the Missouri River runs north and south (Iffrig 1980). The north bank of the river, which crosses the state from east to west, consists of closely related glades and savannas supporting an understory of typical hill prairie grasses (Nelson 1985) but differs from hill prairies owing to a considerable tree component. In Illinois hill prairies prevail mainly on the Mississippi, Illinois and Sangamon Rivers and the largest ones have been mapped by the Illinois Natural Areas Inventory (Schwartz et al. 1997). In Wisconsin hill prairies are termed "dry prairies" and occur overlooking the Wisconsin, Chippewa and St. Croix Rivers, as well as the Mississippi and their distribution has been described by Epstein (personal communication, July 2011).

Evers landmark publication (1955) sparked major ecological interest in these unique communities in Illinois. In the ensuing five decades many scientific studies have shown both the unusual characteristics of their habitat (Reeves et al. (1978) as well as their ephemeral nature in today's climate (McClain 1983, McClain and Anderson 1990, Robertson et al.1995, Schwartz et al. 1997, McClain et al. 2009). These studies show that the major reason hill prairies exist where they do is due to the vastly different microclimate from their surroundings. The air, soil temperature, and evaporation are far higher on these sun-facing slopes and the humidity is much lower than those features in the adjacent forest promoting more frequent and severe drought conditions (Ranft and Kilburn 1969, Reeves et al. 1978). Furthermore these locations are highly exposed to wind, and thus subject to even more rapid drying.

Little attention has been paid to two fundamental questions. First, when and how did hill prairies originate? And second, how have they been maintained over the centuries since their probable origin? The answer to the first question is necessarily brief owing to its taking place in the distant past and therefore lacking solid evidence. The answer to the second is based on our understanding of pre-settlement vegetation, of present decline of hill prairies, and past culture of Native Americans in the Midwest.

Origin of Hill Prairies

The Midwestern prairies expanded to their largest size in Illinois, Indiana, and Ohio during the warmer and drier climatic periods following glaciation from about 8500 BP to about 6000 BP (King 1981, Nelson

[1] Jefferson County Nature Association (JCNA), 6695 Terry Court, Arvada, CO 80007.

Figure 1. Hill prairie distribution along major rivers in the Midwest. Actual prairie habitats and hence locations scattered within the indicated shaded areas generally on high south-facing hills overlooking the river valleys. Vegetation overlooking the Missouri River that extends east and west across the State is shown in black. Vegetation in this area contains considerable tree cover and classified as savannas and glades.

et al. 2006). Since that time cooling and increased moisture reduced these prairies to those seen and mapped as the prairie peninsula by Transeau (1935).

It is likely that the xeric hill prairies reached their greatest size during this period, as the warmer and drier microclimate favored grassland over woody plants. This microclimate favored xeric prairie plants such as little bluestem (*Schizachyrium scoparium*) and side oats grama (*Bouteloua curtipendula*), which dominated these grasslands, but which supported many other dryland grasses and forbs, including the more western prickly pear cactus (*Opuntia humifusa*). Scientific names follow Mohlenbrock (2002).

Maintenance of Hill Prairies

Native Americans burned vegetation as a management tool. This has been well documented, particularly in New England (Cronon 1983, Day 1953). Eyewitness records show that these forests were burned annually and often twice a year, using ground fires to clear out forest underbrush. Such burning was done to lessen insect abundance, facilitate hunting and travel, and open the woods to support more wildlife and several other reasons (Williams 2003). Open forest and openings in the forest provided much more food for wildlife, and greatly improved the carrying capacity for game animals.

There is less eyewitness documentation in the Midwest than in the northeast. Charcoal, clearly the residue from former woody plants and likely forest has been found in several locations (Nelson et al. 2006). In addition, fire scars from pre-settlement trees (McClain and Elzinga 1994, McClain et al. 2009) show that most of this area was also frequently burned. Post oak fire scars in the 18th century in Hamilton County, IL occur on average more frequently than every three years. Fires were perhaps possibly even more frequent than that as many light fires may not have caused fire scars on the trees. Regardless, this recorded frequency suggests that much of Illinois was burned biennially and perhaps even annually in many areas.

Not only do the extensive upland prairies attest to frequent burning, but the abundance of barrens and open forest also show that prairie fires spread into the surrounding woods. In southwestern Illinois fire compatible hazel (*Corylus americana*) was the dominant understory shrub of Illinois forests at the time of the GLO survey in the early 1800's (Kilburn et al. 2009, Kilburn and Brugam 2010), while today that shrub is barely present in the same areas. This shrub is fire compatible and readily sprouts after fires. In today's fire free forest it has been largely shaded out.

Starting fires was probably as important to Native Americans as their use of bows and arrows (Stewart 2002). Fires were started in several ways. Most difficult to master was the use of an upright dowel, spun rapidly by rubbing hands together on a very dry piece of wood. The point of contact was surrounded with very dry materials, and the spark was blown gently to create a small flame. Constant practice made this method rather easy. When available they carried bags of flints, and in later years, flints and steel were used to get sparks. They sometimes carried coals or embers with them from site to site and then wrapped dry grasses or other materials to start the fire. Once they had a small fire, they fed the new fire with larger and larger sticks and fallen branches until they had a blaze that could rapidly spread up slopes and across ridges. Dry leaf litter was an abundant fuel to spread fire in woodlands, and in dry windy weather such fires spread rapidly. When the fire reached the hill prairie grassland, it burned vigorously, doing little or no harm to the usually dormant grasses and forbs, but often damaging and killing woody plants. Repeated burns on these uplands eventually eliminated woody plant invaders everywhere but in the more protected ravines. Hill prairies remained open as long as regular burning occurred.

It is doubtful that many of these fires were lightning caused, as is the frequent feature in the more arid forests of the west. Natural prairie fires were rarely noted, primarily because lightning strikes were nearly always accompanied by rain that would put out any fires that had been started. In Kentucky only one percent (10 of 871) of the fires recorded by the U.S. Forest Service were natural fires started by lighting (Delcourt et al. 1998). Furthermore, the small size and isolation of hill prairies located high above major rivers strongly suggests very little natural fire impact. At the crest of hill prairies lightning may have ignited punky wood in trees that withstood any accompanying rain, but it is doubtful that such lightning strikes caused more than a few of these fires.

Native American Villages in the Region

Were the number of Native Americans and their locations sufficient to completely burn the vegetation of a particular area? Judging from the kind of vegetation existing at the time of the GLO Survey, we can be confident of a positive answer. We know that Native American villages occurred at the base of the bluffs and hills in the rich bottomlands for over the past 10,000 years (Struever and Holton 1979, Farnsworth 2000). It is possible that additional archeological exploration will reveal many such villages in similar habitats, although seasonal shifting villages may leave little permanent evidence. Native Americans traveled several miles from their villages to hunt, and many of their fires could have been many miles from home sites.

River valleys have frequently been the location of choice for settlement by Native Americans. Streams cut through the hills and limestone bluffs leading to the rivers provided drinking water, the first requirement for village location. Such locations could also supply the second necessity, an ample food supply, was readily available from the locally abundant plant and animal food resources. Extensive spring and fall waterfowl migrations, ample fish and shellfish supplies, diverse bottomland, upland and ravine wildlife, and elevated floodplain locations suitable for agriculture provided more than adequate food supplies for Native Americans. A further advantage in this region was the proximity to a major river for trading with other tribes. All these resources and conditions provided ideal living conditions for native inhabitants. There were certainly accidental fires to supplement those intentionally started in these lowland areas close to the steep hillsides. Native Americans were far better at starting fires than putting them out. Villages undoubtedly maintained continuous fires for cooking and heating purposes both inside and outside their homes. During dry periods, especially in the spring and fall, the hillside undergrowth formed an abundant source of dry tinder and burnable material. In windy weather sparks from outdoor fires could have accidentally ignited the tinder and rapidly burned upslope, eventually reaching the hill prairies.

Bluff Top Burials

It is attractive to conclude that perhaps Native American burials in these hill prairies could have been a major factor in keeping the hill prairies open, for burials were exceedingly abundant in the hill prairies and the disturbance caused by these excavations, coupled with intentional fires to keep the prairies open, and could perhaps have been a major factor. An early history of Jersey County, IL (Hamilton, 1919) said this regarding the frequency of mounds and burial places:

> *The limestone bluffs along the Mississippi and Illinois rivers … are capped with fifty or sixty feet of loess, a formation of marly sand and clay, which intersected by deep ravines, separated by narrow ridges, which terminate in bald knobs, hundreds of feet above the river, forming a prominent feature of the landscape. Nearly every one of these high, bald knobs is an ancient burial place and contains human bones. Many of the natural elevations were made artificially higher to form a mound of the remains of the dead.*

Since Euro-American settlement in the early 1800's, many of these sites have been excavated by archeologists seeking information on Native American settlement. (Unfortunately, since then many have been vandalized as well). For example, in Jersey County, Illinois, McAdams (1880) described in detail excavation of a mound atop a bluff ridge near the Illinois River. He stated that mound excavation yielding abundant skeletons had taken place over many years. Titterington (1935) noted the density of some of these burial mounds. He excavated some 39 mounds on a single bluff top overlooking the entrance of Otter Creek into the Illinois River floodplain in Jersey County, IL. A single hill prairie could have many burial mounds and many were only an average of 150 m from each other (Perino 2004). With such burial density and with our knowledge of the Native Americans reverence for ancestral graves, one might understand why these people burned the hill prairies to prevent woody plant invasion. In this way, even as climate change favored woody plant growth on these sites, hill prairies could have been kept free of woody plants, with forest outliers limited to ravines and back slopes of these hills.

Thus, over a considerable period, burning around these burial sites may well have been one means of preventing woody plant invasion over a considerable period. But these burials ended over 2000 years ago (Perino 2004) and could not have been the only contribution to hill prairie maintenance since that time. Bluff top burial and subsequent burning may have contributed to keeping hill prairies open at times, but could only have been a peripheral cause of long term maintenance.

Hill Prairies after Euro-American Settlement

What kept the hill prairies open through the two centuries following Native American expulsion to west of the Mississippi River? Early Euro-American settlers had a decided impact on hill prairies during these years. They not only burned the woods surrounding the hill prairies, often accidentally, and such burning could also have spread to the hill prairies. Furthermore, fence posts in and around these hill prairies prior to 1950, as well as photos of cattle, sheep and goat grazing, provide evidence that grazing took place (Nyboer 1981). Hill prairies were often called "goat prairies" and, assisted in the early years by unchecked fires, resulted in the prairies noted by Braun (1950) and Evers (1955). Photographs taken around the turn of the century show not only open hill prairies, but also a much more open woodland surrounding these prairies (McClain and Anderson, 1990). The hill prairies in 1950 were larger than they are today and may well have approximated those that covered these sites for the previous several thousand years.

Certainly some grazing and browsing by native elk, deer and bison occurred continuously on these hill prairies throughout the last millennia but their impact must have been negligible compared to fire.

Fire and the Future of Hill Prairies

Despite the unusually hot and dry microclimate of these habitats, hill prairies will support forest vegetation and woody plant invasion is causing them to disappear at an alarming rate. Many studies show that this is due to the absence of fire and grazing, and without sound management using these and other tools, the subsequent invasion of woody vegetation will continue (McClain and Anderson 1990, Robertson et al. 1995, Schwartz et al. 1997, and McClain et al. 2009). Aerial photo comparison from 1938 to 1998 shows the total disappearance of some and large size reduction, often greater than 50%, of others. For several decades ecologists considered hill prairies to be among the most stable and permanent prairie systems because of their remote locations and unsuitability for agriculture or development. It is now clear that all hill prairies will continue to shrink or vanish over the next few decades, unless they are managed to prevent woody plant invasion. As shrubs and trees invade, grow and spread, hill prairies are reduced in size. Shading, with the invasion of typical forest understory plants, eliminated the unique assemblage of grass and forb species that make hill prairies so special. Only those sites that have been managed through controlled burning, tree and shrub cutting, grazing and herbicide application will remain as viable, high quality examples of the hill prairies that were once extensive on the river bluffs and hills.

DISCUSSION

Shortly after the end of the last glacial period, during the warmest and driest postglacial interval, extensive upland prairies were established throughout the Midwest in and beyond an area termed the Prairie Peninsula. These grasslands extended through much of Illinois and Indiana, and even into Ohio, and remained the dominant upland vegetation type until plowed and planted by the Euro-American farmer.

At the same time hill prairies were established on the south-facing slopes of bluffs and hills above major rivers, including primarily the Mississippi, Illinois, Sangamon, Missouri and Wisconsin Rivers. On these slopes were the hottest and driest microclimates in the region, and these microclimates favored xeric grassland over tallgrass prairie.

As the climate became cooler and moister, creating a climate more favorable to forest than grassland, shrubs and trees began to encroach on these hill prairies. Only frequent burning, which killed or damaged invading shrubs and trees, could maintain these small prairies as grassland.

Frequent fires were started by the Native Americans inhabiting these areas for fire was their main tool to manage forests. In these deciduous forests these fires were mainly ground fires, as crown fires did not occur. It seems clear that hill prairies owe their persistence to aboriginal fires, intentional and unintentional, originating both on the floodplain or ravine valleys below these prairies and by upland prairie fires that spread through surrounding forest. In most cases the fire path would have been a direct one going up ravines with their dense highly flammable leaf cover. Once started, the fire would create its own wind and burning would spread far and wide engulfing the hill prairies.

Early settlers continued some burning of the vegetation, and in addition, introduced grazing to the hill prairies. With the disappearance of these practices over the last century these grasslands have become invaded and overgrown with woody plants and will become a lost community unless properly managed.

Microclimate alone is not sufficient to keep hill prairies as open grassland.

LITERATURE CITED

Braun, E. L. 1950. Deciduous forests of eastern North America. The Blakiston Co., Philadelphia. 596 pp.

Cronon, W. 1983. Changes in the land: Indians, colonists, and the ecology of New England. Hill and Wang, NY. 241 pp.

Day, G. M. 1953. The Indian as an ecological factor in the northeastern forest. Ecology 324:329–346.

Delcourt, P. A., H. R. Delcourt, C. R. Ison, W. E. Sharp, and K. J. Gremillion. 1998. Prehistoric human use of fire, the eastern agricultural complex, and Appalachian oak-chestnut forests: Paleoecology of Cliff Palace Pond, Kentucky. American Antiquity 63(2):263–278.

Evers, R. A. 1955. Hill prairies of Illinois. Bulletin of the Illinois Natural History Survey 26(5):366–446.

Farnsworth, K. B. 2000. The Woodland Period. Illinois Antiquity 35(3):8–9.

Hamilton, O. B. 1919. History of Jersey County, Illinois. Munsell Publishing Co., Chicago. 1028 pp.

Iffrig, G. F. 1980. Distribution and ecology of Loess Hill Prairies in Atchison and Hold Counties in Northwestern Missouri *in* Proceedings of the Seventh North American Prairie Conference. Southwest Missouri State University, Springfield, Missouri.

Kilburn, P., B. Tutterow, and R. B. Brugam. 2009. The tree species composition and history of barrens, identified by government land surveyors in southwestern Illinois. Journal of the Torrey Botanical Society 136:272–283.

Kilburn, P. and R. B. Brugam. 2010. How natural is nature? The effect of burning on presettlement vegetation in west-central Illinois. The Confluence. Spring/Summer 2010:42–55.

King, J. E. 1981. Late Quaternary vegetational history of Illinois. Ecol. Monographs 51(1):43–62.

McAdams, W. 1880. Ancient mounds of Illinois, 710–718 *in* Proceedings of American Association for the Advancement of Science.

McClain, W. E. 1983. Photodocumentation of the loss of hill prairie within Pere Marquette State Park, Jersey County, Illinois. Transactions of the Illinois Academy of Science 76:343–346.

McClain, W. E. and E. A. Anderson. 1990. Loss of hill prairie through woody plant invasion at Pere Marquette State Park, Jersey County, Illinois. Natural Areas Journal 10(2):69–75.

McClain, W. E. and S. L. Elzinga. 1994. The occurrence of prairie and forest fires in Illinois and other Midwestern states, 1679 to 1854. Erigenia 13:79–90.

McClain, W. E., A. C. Moorehouse, and J. E. Ebinger. 2009. Loss of Hulsebus loess hill prairie, Henderson County, Illinois to woody plant invasion. Transactions of the Illinois Academy of Science 102:141–147.

McClain, W. E., T. L. Esker, B. R. Edgin, G. Spyreas, and J. E. Ebinger. 2010. Fire history of a post oak (*Quercus stellata* Wang.) woodland in Hamilton County, Illinois, U.S.A. Castanea: 75(4):461–474.

Mohlenbrock, R. H. 2002. Vascular Flora of Illinois. Southern Illinois University Press, Carbondale and Edwardsville, Illinois. 490 pp.

Mutel, C. F. 1989. *Fragile Giants*. University of Iowa, Iowa City, Iowa. 284 pp.

Nelson, D. M., F. S. Hu, E. C. Grimm, B. B. Curry, and J. E. Slate. 2006. The influence of aridity and fire on Holocene prairie communities in the eastern Prairie Peninsula. Ecology 87(10):2523–2536.

Nelson, P. W. 1985. The terrestrial natural communities of Missouri. Missouri Natural Areas Committee, Jefferson City, Missouri.

Novacek, J. M., D. M. Roosa, and W. P. Pusateri. 1985. The vegetation of the Loess Hills landform along the Missouri River. Proceedings of the Iowa Academy of Science 92(5):199–212.

Nyboer, R. W. 1981. Grazing as a factor in the decline of Illinois hill prairies, 209–211 *in* The prairie peninsula in the "shadow" of Transeau: Proceedings of the Sixth North American Prairie Conference. Ohio Biological Survey Biological Notes.

Perino, G. 2004. Illinois Hopewell and Late Woodland mounds. The excavations of Gregory Perino: 1950–1975. Studies in Archaeology 4, University of Illinois Press, Urbana, Illinois.

Ranft, C. and P. D. Kilburn. 1969. Evaporation contrasts between south-facing bluff prairies and north-facing forest. Transactions of the Illinois Academy of Science 62(1):5–90.

Reeves, J. T., U. D. Zimmerman, and J. E. Ebinger. 1978. Microclimatic and soil differences between hill prairies and adjacent forests in East-Central Illinois. Transactions of the Illinois Academy of Science 71:156–164.

Robertson, K. R., M. W. Schwartz, J. W. Olson, B. K. Dunphy, and H. D. Clarke. 1995. 50 years of change in Illinois hill prairies. Erigenia 14:41–52.

Schwartz, M. W., K. R. Robertson, B. K. Dunphy, J. W. Olson, and A. M. Trame. 1997. The biogeography of and habitat loss on hill prairies. Conservation of Highly Fragmented Landscapes. Chapman & Hall, New York. 267–283.

Stewart, O. C. 2002. Forgotten Fires, Native Americans and the transient wilderness. University of Oklahoma Press, Norman, Oklahoma. 364 pp.

Struever, S. and F. A. Holton. 1979. Koster: Americans in search of their prehistoric past. Anchor Press/Doubleday, NY.

Titterington, P. F. 1935. Certain bluff mounds of western Jersey County, Illinois. American Antiquity 12(1):6–46.

Transeau, E. N. 1935. The prairie peninsula. Ecology 16:423–437.

Williams, G. W. 2003. References on the American Indian use of fire in ecosystems. Washington, D. C.: USDA Forest Service.

INVITATION FOR SUBMISSION OF ARTICLES

Erigenia is a peer-reviewed journal of the Illinois Native Plant Society. We invite the submission of original articles on the biota of Illinois and adjacent states. This is a partial list of articles of interest to society members.

Taxonomy of vascular plants, fungi, lichens, and mosses

Ecology of native species and plant communities; interactions and effects of birds, mammals, and insects on our ecosystem

Natural History of our state, including geology and geography

Ethnobotany of native plants, their use by Native Americans

Cultural History as it intersects with natural history

Botanists, Scientists, Explorers, and Botanical Artists who have played a major role in our understanding of our state and its natural resources

Restoration of our native landscapes, management techniques and results

Horticulture as it relates to native plants in restored or cultural environments

INSTRUCTIONS FOR AUTHORS

Authors may submit material as an e-mail attachment to erigenia.editor@gmail.com

Manuscripts must be submitted as an MS Word document in a single font, double-spaced, and left-aligned. Tables and illustrations must fit in a 7 x 9 inch area. Authors should retain copies of all material submitted.

The title page of the manuscript should state the affiliation and complete addresses of all the authors; the telephone number of the corresponding author should also be supplied. All papers will be reviewed and copy-edited.

ABSTRACTS

Research and technical papers should include a one-paragraph abstract of not more than 250 words. The abstract should state concisely the goals, principal results, and major conclusions of the paper.

TAXONOMIC NAMES

Either a standard taxonomic manual should be cited whose names are followed consistently, or the scientific names should be followed by their authority. Common names, if used, should be referenced to a scientific name. Thereafter, scientific names are recommended, but either may be used if done so consistently.

PAGE CHARGES

Page charges for society members are $50.00 per article. Page charges of $25 per page will be assessed for non-members.

Contents