ERIGENIA

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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.

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.

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COVER ILLUSTRATION

Original drawing of *Apios americana* Medik. (groundnut or wild potato) by Nancy Hart Stieber.

Nancy received her art education from The Art Institute of Chicago, but much of her botanical and natural history education she attributes to her study with Ray Schulenberg, whom she accompanied on many field forays in the prairie and dune regions of Illinois and Indiana.

MEMBERSHIP

Yearly membership includes a subscription to ERIGENIA and the quarterly newsletter, THE HARBINGER. For more information, write to

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In the case of groundnut, we are able to retrieve some grasp of its former significance to Native Americans by the fact that when certain tribes became acquainted with the "Irish" potato, *Solanum tuberosum* L., they applied to it the word in their language that they had previously used for groundnut. This transfer of a familiar word to a new object is an alternative to trying to incorporate a new word into the language.[2]

LINGUISTIC CONSIDERATIONS

The Siouan Languages

Specific cases of the transfer of the indigenous name for groundnut to the introduced potato are available to us in certain Siouan languages that happen to be fairly well documented. The following is from Riggs (1890):

> mdo, n., an esculent root eaten by the Dakotas, in appearance and taste something like sweet potatoes, the Dakota *tamdo*; potatoes, the Waśićuŋ *tamdo*.

Waśićuŋ is European man, and the prefix *ta* is the sign of third-person genitive, "his". The entry above is for the eastern or Santee Dakota. The western or Teton Dakota (Lakota) use the phoneme *l* in place of the Santee *d*, and their word for potato is *blo*. The entry for *blo* in Buechel (1983) is interesting:

> An esculent root eaten by the Dakotas, in appearance and taste like the sweet potato; potatoes. The *opers tuberosa*.

The explanation for the puzzling last two words is that Father Buechel, who knew both Lakota and plants fairly well, did not live to see his dictionary published, and the Jesuit brother who was assigned the task of editing the dictionary miscopied Buechel's handwritten *Apios* as *opers; Apios tuberosa* is, of course, a synonym of *Apios americana*, groundnut. The Santee lived in Minnesota in historic times, and although the Tetons roamed west far beyond the range of groundnut, they no doubt remained familiar with the plant through visits with their eastern relatives.

For the Siouan-speaking Winnebago (Hochank), Gilmore (1919) recorded the name of groundnut as *tdo*; the pronunciation of this is uncertain.

Moving south to the Siouan-speaking Osages of Missouri, we find the following in LaFlesche (1932), here quoted in full:

> do, potato. Before the Irish potato was introduced by traders, the Osage used a wild potato which tastes like sweet potato. When the Irish potato became known to the Osage they applied to it the name "do" (*Glycine apios*). The "do" is mentioned in one of the tribal rituals as a sacred food.

Glycine apios is, of course, another synonym of *Apios americana*.

Siouan-speaking tribes lived as far south as the Gulf of Mexico, and when their languages were finally studied, their word for potato was found to be cognate with that of the Dakota. According to Dorsey and Swanton (1912), for the Biloxi tribe we have the word *ado* (or *ato* with unaspirated *t*.) For the Ofo, a neighboring southern tribe, we have *ato*. These authors reported that the Ofo distinguished between the Irish potato and the "wild or marsh potato" by appropriate modifying words. Although they do not give us a scientific name for this wild plant, there can be little doubt that it is *Apios americana*.

The derivation of the name of Topeka, the capital of Kansas, is relevant to our discussion of groundnut. The question, argued pro and con in Rydford (1968), is whether or not Topeka means something like "groundnut good digging" in one or more Siouan languages. Vogel (1962) has an entry for Topeka, Illinois (named for Topeka, Kansas); he favors the groundnut hypothesis for the origin of the name, and I, after much sifting of evidence, agree.

The Hidatsa are a Siouan-speaking people, and it may be significant that their word for potato is not a variation of the familiar *do/to,* but rather *kaksha* (Matthews 1873). This could well be the result of the centuries-long residence of the Hidatsa well north and west of the range of groundnut. As for the Mandan, long-time good neighbors of the Hidatsa, their name for potato seems not to be in the extant literature.

The Algonquian Languages

The *Apios-Solanum* linkage runs a parallel course in the Algonquian linguistic family—a grouping originally even more extensive geographically than the Siouan. I first encountered this botanical dichotomy in 1946 while living on the reservation of the Prairie Band Potawatomi near Mayetta, Kansas. These are descendants of people

[2] The word "potato" itself is an English mispronunciation of a Taino Indian word that originally referred to the sweet potato, *Ipomoea batatas* (L.) Lam., which grew natively in the Taino homeland of the greater Antilles and the Bahamas. The Irish potato, of course, was domesticated by the native peoples of the South American Andes, taken to Europe by the Spanish, and introduced into North America by European settlers.

who lived mostly in northern Illinois and southern Wisconsin until about 1836. At feasts in Kansas I was pleased to partake from bowlfuls of tastily cooked groundnut. At that time most of the Indian residents of the reservation still spoke the Potawatomi language. To them, this dish was *nishnabe piniak,* which they translated "Indian potatoes." The word *nishnabe* distinguished groundnuts from Irish potatoes, which by that time, to these folks, were simply *piniak.* A variation of this usage is found in Huron Smith's work on the Forest Potawatomi of Wisconsin. He reported (1933) that they distinguished *Apios americana* as *mukwopinik,* bear potato.

Central Algonquian names for potato, presumably all having referred originally to groundnut, contain the syllable *pin* or *pen.* Meeker, Elias, and Heim (1993) quite explicitly apply the Ojibwe word *opin* to *Apios americana;* most Ojibwe dictionaries translate *opin* as potato, leaving us to extrapolate groundnut as the original meaning. For the Mesquakie (Goddard 1994), we have the word *ahpenya,* and for the closely related Kickapoo (Voorhis 1988), *ohpenya;* for the Menominee, *ohpe̋nyak* (plural), this from Bloomfield (1975). Erichsen-Brown (1979) quotes a 1590 description by Thomas Harriot, of what is unquestionably *Apios americana,* with the Virginia Indian name of *openask,* a clear testimony to the wide range of both groundnut and Algonquian speakers.

One is tempted to speculate as to whether the *pen/pin* syllable in proto-Algonquian was limited in meaning to groundnut, or had a general reference to, say "edible underground plant part." Smith (1933), for instance, gives *wagipin* (crooked potato) as the Forest Potawatomi name for the edible storage shoots of lotus, *Nelumbo lutea* (Willd.) Pers. Swanton (1946) quotes the linguist Truman Michelson as saying that Algonquian *penauk,* etc. meant "root"; in this Michelson was probably mistaken.

The Muskhogean Languages

As for the three Muskhogean tribes for which I have lexical material, again we see a similarity in their words for potato, which suggests familiarity of these three peoples with a potatolike plant before they separated. In the Alabama language (Sylestine, Hardy, and Montier 1993) the word *aha* means potato and sweet potato; in Choctaw (Byington 1915), *ahe* covers both Irish potato and sweet potato, and in Chickasaw (Monroe and Willmand 1994), *ahi'* is the basic word for potato.

The Iroquoian Languages

I have less access to Iroquoian linguistics, but I feel that the resemblance between *nuna,* a Cherokee name for potato (Feeling 1975) and *-none't,* meaning potato in Seneca (Chafe 1967), is no coincidence, but rather points back to a time when these two tribes, now remote, descended from a common ancestral people who knew a potatolike plant, very likely *Apios americana.*

The Caddoan Languages

Caddoan linguistic material is scarce. We know that the groundnut was important to the Pawnee of Nebraska. Their name for it was the monosyllabic *its* (also spelled *ic*). Their name for the Loup River, heart of the Skidi Pawnee homeland, was *ickari,* meaning "lots of groundnuts" (Weltfish 1965; Murie 1981). What we don't know in this case is whether the Pawnee transferred this name for groundnut to Irish potato; I have not found this information in print.

Native American words for groundnut by language group and tribe

SIOUAN	
Eastern or Santee Dakota	mdo
Western or Teton Dakota (Lakota)	blo
Winnebago	tdo
Osage	do
Biloxi	ado
Ofo	ato
Hidatsa	kaksha
ALGONQUIAN	
Prairie Band Potawatomi	nishnabe piniak
Forest Potawatomi	mukwopinik
Ojibwe	opin
Mesquakie	ahpenya
Kickapoo	ohpenya
Menominee	ohpe̋nyak
Virginia	openask
MUSKHOGEAN	
Alabama	aha
Choctaw	ahe
Chickasaw	ahi'
IROQUOIAN	
Cherokee	nuna
Seneca	-none't
CADDOAN	
Pawnee	its or ic

NUTS AND OTHER TUBEROUS PLANTS

In spite of the English common name groundnut, I find no evidence that any native people conceived of *Apios americana* as a nut. For instance, Algonquian words such as *bagaan* and *pakani* (from which obviously we derive pecan), were not applied to *Apios americana*.

Although explorers, traders, missionaries, and even linguists are seldom versed in botany, it is usually possible to recognize references to groundnut because of the distinctive feature of numerous tubers strung at intervals along the rhizome (or root). Occasional observers have confused this species with prairie turnip, *Psoralea esculenta* Pursh (= *Pediomelum esculentum* (Pursh) Rydb.), also a legume. That perennial, however, does not climb, and has only a single swelling in a vertical taproot. It was even more sought after than groundnut by Indians of the prairie. I have always found it puzzling that the Dakota, upon encountering prairie turnip, did not give it a name reflecting its resemblance and relationship to *Apios americana*. Instead, they called it *tiŋpsiŋna*, which translates "prairie rice," seeming to imply that the Dakota regarded *Psoralea esculenta* as the nutritional equivalent of wild rice, *Zizania aquatica* L., which is a grass and a food staple of the Dakota in Minnesota.

A few observers have confused groundnut with Jerusalem artichoke, *Helianthus tuberosus* L., a native composite with barely palatable tubers. However, the linguistic evidence is that all the Native Americans who knew that plant had names for it quite distinct from those for groundnut, and never transferred *Helianthus* names to the Irish potato.

EVIDENCE OF CULTIVATION

Considering the food value of groundnut tubers, it may seem odd that this species was not brought into cultivation by Native Americans, and that it has not become a staple of modern agriculture. There are references to consumption of the tubers by early settlers, and attempts at cultivation. There is also mention of Indians planting tubers in suitable places; indeed, we cannot rule out the possibility that some existing populations of the plant may result from early Indian transplanting, which may well have extended its range. It is especially intriguing to speculate that some of the westernmost stations for groundnut may represent plantings by Indian tribes as they migrated west in protohistoric times. Kelly Kindscher (1987) comments on this appealing subject in his extensive and well-researched entry on this species.

As a generalization, Native Americans in what is now the eastern United States and southeast Canada regularly cultivated corn, beans, squash, and sometimes sunflowers and tobacco—all summer annuals that bear their harvestable crops above ground. Roots and tubers, perennial herbs, and the fruits and nuts of woody plants were harvested from wild populations.

There have been experiments by European man to cultivate groundnut for the edible tubers, but without notable success. At present it is available from a few nurseries as an ornamental or novelty.

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THE AVENS SPECIES (*GEUM* L., ROSACEAE) OF ILLINOIS

Michael B. Wenzel[1] and John E. Ebinger[2]

ABSTRACT: A principal-components analysis of 126 herbarium specimens representing the morphological and geographical range of the genus *Geum* L. in Illinois revealed that the 7 native species of avens are distinct. Of these taxa, *Geum canadense* Jacq. is the most common, being reported from every county. Of the remaining species, *G. vernum* (Raf.) Torrey & Gray and *G. laciniatum* Murray, are wide ranging, and found throughout most of Illinois, while *G. triflorum* Pursh and *G. aleppicum* Jacq. are restricted to the extreme northern part of the state. The very rare *G. rivale* L. is probably extirpated from Illinois. The often overlooked *G. virginianum* L. is scattered in the southern third of Illinois; its similarity to *G. canadense* probably is responsible for the few collections. A probable F_1 hybrid between *G. canadense* and *G. laciniatum* has been found in the state. A key to the native avens of Illinois is given, along with distribution maps.

INTRODUCTION

The genus *Geum* L. is represented worldwide by about 60 species, distributed primarily in the Northern Hemisphere, where species are particularly common in alpine, arctic, and boreal regions (Gajewski 1959). Approximately 17 species occur in North America; 7 of these are native to Illinois (Robertson 1974; Mohlenbrock 1986). The genus *Geum* is characterized by the following morphological features: herbaceous perennials with basal rosettes of leaves, most species also with cauline leaves; leaves pinnately compound, generally lyrate in outline, the terminal leaflet larger than the lateral ones, some lower lateral leaflets often greatly reduced in size; flowers perfect, 5-merous, the hypanthium mostly saucer shaped, the calyx usually with an epicalyx (bracts so closely placed beneath the calyx as to suggest an additional calyx), the stamens numerous, the carpels numerous on a cylindrical receptacle, the achenes with persistent, elongated, plumose or hooked styles; base chromosome number x = 7, the Illinois species hexaploids with 2n = 42 (Robertson 1974; Mohlenbrock 1986; Kalkman 1988).

Geum triflorum (prairie smoke)

The genus *Geum* is commonly placed in the tribe Dryadeae, subfamily Rosoideae, family Rosaceae. Within this tribe, the genus *Geum* and the genera *Fallugia* Endl. and *Waldsteinia* Willd. appear to be closely related, all having a base chromosome number of x = 7. Although not universally accepted, there is mounting evidence that a tribe composed of the above 3 genera might be an accurate representation of their phylogenetic relationship (Kalkman 1988; Morgan, Soltis, and Robertson 1994).

Although the *Geum* species of Illinois are quite distinct, artificially produced hybrids are common (Raynor 1952; Gajewski 1957; Robertson 1974). Many of these hybrids are fertile, but naturally occurring hybrids are rarely reported. The

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present study was undertaken to examine the relationships among the *Geum* species found in Illinois, to determine their geographic distribution in the state, to determine if hybridization occurs, and to distinguish any subspecific taxa of these species.

METHODS

Nearly 1,000 herbarium specimens were examined from many of the state herbaria (DEK, EIU, F, ILL, ILLS, MOR, MWI, SIU). Habitat observations also were made for most species, and specimens were collected. From this material, dot distribution maps were prepared. Each dot on these maps represents a specimen examined by the authors (fig. 1).

The examined specimens were sorted into groups based on similarity of morphological characters. From these groups, a total of 126 specimens representing the morphological and geographic range of each taxon in Illinois were scored for 3 vegetative and 11 floral and fruit characters (table 1). These 126 specimens comprised 20 each of *G. aleppicum, G. canadense, G. laciniatum, G. triflorum,* and *G. vernum,* 13 of *G. rivale,* 12 of *G. virginianum,* and 1 proposed hybrid specimen. For some species, out-of-state specimens were included in the analysis when few in-state specimens were available. All characters were measured (3 or more measurements or observations per character for each specimen) and plotted to confirm the existence of gaps to enable the use of scored characters. The data were then analyzed by principal-components analysis (PCA) using NTSYS-pc (Rohlf 1990).

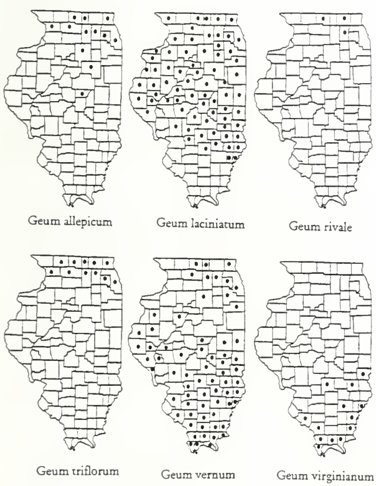

Fig. 1. Maps showing the distribution of the native species of *Geum* in Illinois

RESULTS AND DISCUSSION

When the data set containing the 126 herbarium specimens was analyzed by PCA, the first 3 principal components accounted for 47.7%, 20.0%, and 15.1%, respectively, or 82.8% of the total variance. Style pubescence, petal color, and calyx lobe length (characters 12, 8, 4) were the most important in determining the score of the first component; the presence of an obvious stipe, epicalyx presence, and fruiting pedicel width (characters 9, 6, 2) were the most important in determining the score of the second component; and achene length, receptacle pubescence, and petal length (characters 13, 10, 7) were the most important in distinguishing the third component. In the PCA plot (fig. 2), distinct clusters can be recognized that correspond to the 7 native Illinois taxa and the probable hybrid specimen. The clusters do not seem to contain recognizable subgroups, and each cluster is separated from the others. The dots representing the specimens in each group are also closely spaced, indicating that the species are fairly homogeneous.

Barriers to artificial hybridization are nearly nonexistent in the genus *Geum* (Raynor 1952; Gajewski 1957); nonetheless, no hybrids have been reported from Illinois. Potential hybrids involving native Illinois species include *G. aleppicum* × *G. rivale,* reported from northern New York (Rydberg 1913; Fernald 1950), and *G. canadense* × *G. laciniatum,* reported from an experimental garden (Raynor 1952).

During the present study, one specimen was found that is probably a hybrid involving *G. canadense* and *G. laciniatum* (R. A. Evers #34641, Clark Co., wet field, 8 miles south of Marshall, 22 July 1952, ILLS). This individual has the general habit and size of *G. canadense,* along with hirsute receptacles and narrow (less than 0.9 mm wide), puberulent fruiting pedicels. It is similar to *G. laciniatum* in having longer calyx lobes, an epicalyx more than 2 mm long, and mature achenes more than 4 mm long that are sparsely hirsute (like *G. laciniatum* var. *trichocarpum*). The achenes, however, have not developed normally, the lower half being thin walled and shriveled. This probable hybrid specimen was positioned between *G. canadense* and *G. laciniatum* in the PCA plot (fig. 2). When only those 2 species and the hybrid specimen were analyzed by PCA, similar results were obtained, the hybrid falling between the 2 species.

Fig. 2. Plot of axis 1 vs. 2 of a principal-components analysis, using 3 vegetative and 11 floral variables, of 125 specimens of the native *Geum* species found in Illinois and 1 probable hybrid specimen (H)

Table 1. Characters scored for the *Geum* complex in Illinois

1. Stipule margins (1 = entire or with small teeth, 2 = with 1 or 2 lobes, 3 = with 3 or more lobes, 4 = stipules absent)
2. Pedicel width 10–20 mm below fruit (mm)
3. Pedicel pubescence (1 = glabrous or nearly so, 2 = densely puberulent and commonly with a few long hairs, 3 = densely hirsute and usually also puberulent)
4. Calyx lobe length (mm)
5. Calyx lobe position in fruit (1 = reflexed, 2 = erect to ascending)
6. Epicalyx (1 = absent, 2 = present)
7. Petal length (1 = shorter than the calyx lobes, 2 = equal to or longer than the calyx lobes)
8. Petal color (1 = white, 2 = yellow, 3 = pink to purple)
9. Obvious stipe below the head of achenes (1 = absent, 2 = present)
10. Receptacle pubescence (1 = glabrous to puberulent, 2 = hirsute)
11. Fruiting style length (1 = less than 7 mm long, 2 = 7–15 mm long, 3 = more than 15 mm long)
12. Fruiting style pubescence (1 = glabrous, 2 = hirsute at the base to along the lower half, 3 = hirsute throughout)
13. Achene length (mm)
14. Achene pubescence (1 = glabrous to lightly pubescent, 2 = hirsute near the apex, 3 = hirsute along the margins and lightly pubescent on the sides, 4 = hirsute throughout)

KEY TO THE NATIVE AVENS SPECIES

1. Flowers purplish or rose pink in color; sepals erect or ascending in fruit.
   2. Mature styles more than 14 mm long, not jointed; plants subscapose . . . 1. *Geum triflorum*
   2. Mature styles less than 14 mm long, jointed above the middle; cauline leaves well developed . . . . 2. *Geum rivale*
1. Flowers with the petals white to bright yellow; calyx green to greenish; sepals reflexed in fruit.
   3. Epicalyx absent; aggregate of achenes elevated above the calyx on a stipe 2–5 mm long . . . . 3. *Geum vernum*
   3. Epicalyx present; aggregate of achenes sessile.

4. KEY TO FLOWERING MATERIAL.
   5. Petals shorter than the calyx lobes.
      6. Receptacle hirsute; pedicels densely puberulent and with a few scattered long hairs; receptacle hirsute . . . . 4. *Geum virginianum*
      6. Receptacle glabrous to puberulent; pedicels densely hirsute . . . . . . 5. *Geum laciniatum*
   5. Petals equal to longer than the calyx lobes.
      7. Petals white; stipules of the middle cauline leaves not lobed, the margins entire to shallowly toothed . . . . 6. *Geum canadense*
      7. Petals bright yellow; stipules lobed . . . . 7. *Geum aleppicum*

4. KEY TO FRUITING MATERIAL.
   8. Receptacle essentially glabrous; pedicels densely coarse-hirsute; mature achenes mostly more than 4 mm long . . . 5. *Geum laciniatum*
   8. Receptacle hirsute; pedicels densely puberulent and with a few scattered long hairs; achenes mostly less than 4 mm long.
      9. Median cauline leaves pinnately compound with 5–7 leaflets; fruiting pedicels more than 0.9 mm wide; styles hirsute near the base . . . . 7. *Geum aleppicum*
      9. Median cauline leaves simple to trifoliolate; fruiting pedicels less than 0.9 mm wide; style glabrous.
         10. Stipules less than 20 mm long, usually not lobed, the margins mostly entire to toothed . . . . 6. *Geum canadense*
         10. Stipules of the middle and lower cauline leaves mostly more than 20 mm long, lobed 4. *Geum virginianum*

1. *GEUM TRIFLORUM* Pursh (prairie avens, prairie smoke)
In Illinois, prairie smoke is limited to the northern sixth of the state, where it occurs in dry sand and gravel prairies (fig. 1). *Geum triflorum* is distinguished from the other Illinois avens by its subscapose habit and its long, plumose, persistent, unjointed styles. These characters led to its placement in the genus *Erythrocoma* (Greene 1906) and the genus *Sieversia* (Rydberg 1913). Studies indicate that *G. triflorum* is closely related to other *Geum* species, and separation is unwarranted (Raynor 1952; Robertson 1974).

2. *GEUM RIVALE* L. (purple avens)
This taxon, known from swamps, calcareous wet meadows, and bogs, has been reported from 3 counties in extreme northern Illinois (fig. 1), but is now probably extirpated from the state. Purple avens is similar to *G. triflorum,* both taxa having long prostrate stolons, pendulous flowers, erect to ascending calyx lobes, and plumose styles. These attributes also distinguish *G. rivale* from the other avens of Illinois. The jointed style with the distal portion deciduous, the hooked apex of the persistent basal portion of the style, and the aggregate of achenes on a stipe distinguish *G. rivale* from *G. triflorum.*

3. *GEUM VERNUM* (Raf.) Torrey & Gray (spring avens)
A common feature of woodland paths, this species is present in moist woods, thickets, and open disturbed sites. It is extremely common in the southern half of Illinois, becoming less common to the north (fig. 1). Spring avens is easily separated from other avens species by the early flowering period, the small yellowish petals that are shorter than the calyx lobes, the absence of an epicalyx, and the aggregate of achenes elevated on a stipe 2–5 mm above the hypanthium.

4. *GEUM VIRGINIANUM* L. (pale avens)
This taxon grows in moist woods in the southern half of Illinois, where it is uncommon to occasional (fig. 1). Similar morphologically to *G. canadense,* and commonly confused with it, *G. virginianum* differs by having cream-colored to pale yellow petals much shorter than the calyx lobes and lobed stipules more than 20 mm long. Raynor (1952) and Gajewski (1957) suggested that *G. virginianum* originated from hybridization between *G. canadense* and *G. aleppicum,* the artificial F_1 of this cross conforming to the morphology of *G. virginianum,* but being highly sterile. Plants of true *G. virginianum,* however, are fertile and show no segregation in subsequent generations (Robertson 1974). Although *G. virginianum* is always found within the geographic range of *G. canadense,* it is far south of the range of *G. aleppicum* in Illinois (fig. 1). Most examined specimens of this taxon were originally identified as *G. canadense.*

5. *GEUM LACINIATUM* Murray (rough avens)
Common in the northern three-quarters of Illinois, this taxon grows in wet meadows and other wet, open places, rarely forming large colonies (fig. 1). Rough avens is separated from other Illinois avens by white petals that are much shorter than the calyx lobes, the glabrous to puberulent cylindrical receptacles, the densely hirsute pedicels, and the large achenes, which commonly exceed 4 mm in length. Two varieties are recognized by some authors — var. *trichocarpum* Fernald (1935), with sparsely hirsute achenes, and var. *laciniatum* with glabrous achenes. Variety *laciniatum* has been reported from Illinois (Mohlenbrock and Ladd 1978; Mohlenbrock 1986), but all of the more than 160 Illinois specimens examined during the present study keyed to var. *trichocarpum.*

photo by Ken Dritz

Geum laciniatum var. *trichocarpum* (rough avens)

6. *GEUM CANADENSE* Jacq. (white avens)
This taxon is abundant in moist upland and floodplain woods, particularly in disturbed areas and along paths, and it occurs in every Illinois county (Mohlenbrock 1986). The following combination of characters easily separates *G. canadense* from other Illinois avens: small (less than 20 mm long), entire to shallowly toothed stipules, white petals that equal to slightly exceed the calyx lobes, and densely hirsute receptacles. White avens is highly variable morphologically, resulting in Fernald and Weatherby (1922) recognizing 6 subspecific entities. Mohlenbrock (1986) listed 2 of these for Illinois (var. *canadense*, and var. *grimesii* Fern. & Weath.). The numerous Illinois specimens examined do not easily segregate into these 2 varieties because of weak character correlations. Subspecific categories are probably not warranted for this taxon (Gleason 1952; Robertson 1974).

7. *GEUM ALEPPICUM* Jacq. (yellow avens)
Yellow avens is restricted to the northern quarter of Illinois where it grows in tamarack bogs, calcareous fens, disturbed areas, thickets, meadows, and forest clearings (fig. 1). It also appears to be partial to hummocks in marshy areas adjacent to bogs, where cattle have grazed. Differing only slightly from the Eurasian *G. aleppicum*, the North American plants are sometimes distinguished as var. *strictum* (Ait.) Fern. (Fernald 1950; Swink and Wilhelm 1994; Gleason and Cronquist 1991). *Geum aleppicum* is distinguished by its deep yellow to orange petals that exceed the calyx lobes, hirsute receptacles, achenes hirsute nearly throughout, and styles lightly hirsute near the base.

Of the specimens examined, a few were previously identified as *Geum macrophyllum* Willd., a northern species that is not native to Illinois (Fernald 1950; Gleason and Cronquist 1991). These were mostly sterile or poor-quality specimens that were determined to be *G. laciniatum* or *G. aleppicum*, by using the key proposed here. This taxon is distinguished by minute glandular hairs present near the base of the style, glabrous to puberulent receptacles, yellow petals that slightly exceed the calyx lobes, and a usually deciduous epicalyx.

Geum urbanum L., an introduced Eurasian taxon, was first found in Illinois in 1986 (Swink and Wilhelm 1994). It is known from DuPage County, where it occurs in disturbed habitats. It is distinguished by the yellow, 4–5 mm long petals that equal to slightly exceed the calyx lobes, a nearly glabrous terminal style segment, and very large, oval stipules.

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photo by Ken Dritz

Geum canadense white avens

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The Lichen Flora of the Cook County Forest Preserves Part V: Salt Creek Division

Richard D. Hyerczyk[1]

ABSTRACT: Forty-four taxa of lichens (43 species and one variety) are reported for the Forest Preserve District of Cook County's Salt Creek Division, of which 17 were vouchered. An annotated species list is provided, as well as checklists for the individual preserves within this division.

Introduction

This is the fifth paper in the series that started with Hyerczyk (1998)—a project to document the lichenized fungi found in the 12 divisions of the Forest Preserve District of Cook County, Illinois.

Salt Creek Division

The Salt Creek Division is approximately 1,523 hectares (3,763 acres) in size and comprises 25 individual preserves (fig. 1) in the western part of central Cook County. According to Swink and Wilhelm (1994), it lies mainly in the Western Morainal and the Chicago Lake Plain sections of the natural divisions of the Chicago region, and, to a lesser extent, in the Bedrock Valley Section. Part of it runs approximately 8 kilometers (5 miles) east to west along Salt Creek, where elevations above mean sea level range from about 198 meters (650 feet) to 189 meters (620 feet). In this morainal section, plant community types include mesic woodland, oak savanna, and prairie. The Salt Creek Division also runs approximately 7 kilometers (4.5 miles) north to south along the Des Plaines River, into the lake plain, where elevations above mean sea level average 198 meters (650 feet) along the river bluffs and 181 meters (595 feet) along the shoreline. Lake plain plant communities include maple-basswood floodplain forest, mesic woodland, and oak savanna. The southern part of the Salt Creek Division lies in the Bedrock Valley Section, where the dolomite bedrock has been exposed. Man-made features throughout the division include concrete and asphalt roadbeds, picnic tables, and wood rail fences.

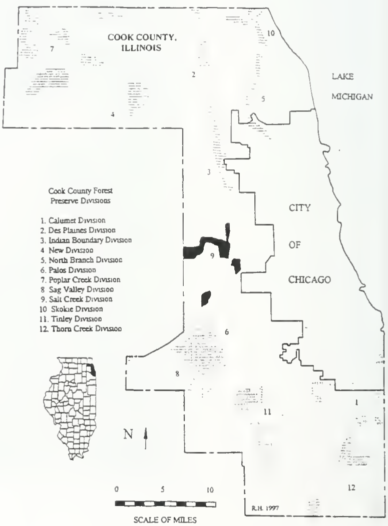

Fig. 1. Salt Creek Division

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MATERIALS AND METHODS

During the fall of 1998, 25 individual preserves were surveyed for their lichen flora. Specimens were identified following methods described in Hyerczyk (1998). In addition, specimens housed at the Morton Arboretum that had been collected previously from the Salt Creek Division were included in this paper. Nomenclature approximates Esslinger and Egan (1995), and concepts follow Wilhelm (1998).

RESULTS

Forty-four taxa of lichens (43 species and one variety) in 33 genera are reported for the Salt Creek Division. Twenty-one lichens are crustose growth forms, 19 are foliose, 3 are fruticose, and one is squamulose. Of the reported taxa, 23% are common, 7% are frequent, 36% are occasional, and 34% are rare. Seventeen taxa were vouchered specifically from the Salt Creek Division.

As in other forest preserve divisions, several taxa were found on the trunks and lower limbs of trees and shrubs growing along sunny paths, or in open situations, where they were more exposed to sunlight than is the case in most contemporary woodland situations. These included *Anisomeridium nyssigenum, Arthonia caesia, Candelaria concolor, Candelariella reflexa, Hyperphyscia adglutinata, Lepraria lobificans, Myelochroa aurulenta, Opegrapha atra, Parmelia sulcata, Phaeophyscia pusilloides, P. rubropulchra, Physcia adscendens, P. millegrana, P. stellaris, Punctelia rudecta,* and *Xanthoria fallax.*

Some lignicolous taxa that were found on decorticate logs, weathered wood fencing, and picnic tables included *Amandinea punctata, Caloplaca microphyllina, Cladonia cristatella, C. macilenta* var. *bacillaris, C. ramulosa, Lecanora saligna, L. symmicta, Phaeophyscia cernohorskyi, Thelocarpon laureri,* and *Trapeliopsis flexuosa.*

The exposed dolomite bedrock, granite boulders, and weathered concrete provided habitat for several crustose lichens. Those growing on dolomite or thin soil over dolomite included *Catapyrenium squamulosum, Protoblastenia rupestris, Sarcogyne regularis,* and *Verrucaria calkinsiana.* Those found on weathered concrete included *Bacidia granosa, Bacidina egenula, Caloplaca feracissima, Endocarpon pusillum,* and *Lecanora dispersa. Lichenothelia* sp. was found on granite erratics.

An alphabetized, annotated list of the lichenized fungi found in the Salt Creek Division follows. Generalized degree of frequency and a brief discussion of habitat is given, followed by a collection number in the case of vouchered specimens. All collections were made by the author, unless otherwise indicated. At the end of each entry, growth form and substrate are listed.

AMANDINEA Choisy *ex* Scheid. & H. Mayrh.

Amandinea punctata (Hoffm.) Coppins & Scheid.
Frequent; on weathered wood fences and on the lower trunks of *Carya ovata* and *Gleditsia triacanthos* f. *inermis.* (crustose; corticolous/lignicolous)

ANISOMERIDIUM (Müll. Arg.) Choisy

Anisomeridium nyssigenum (Ellis & Everh.) R. C. Harris
Occasional; on the trunks of *Crataegus mollis* and *Quercus alba.* (crustose; corticolous)

ARTHONIA Ach.

Arthonia caesia (Flotow) Körber
Frequent; on the lower trunks of *Crataegus mollis, Fraxinus pennsylvanica* var. *subintegerrima,* and *Populus deltoides.* Horn #19 (crustose; corticolous)

BACIDIA De Not.

Bacidia granosa (Tuck.) Zahlbr.
Rare; on weathered concrete. (crustose; saxicolous)

BACIDINA Vězda

Bacidina egenula (Nyl.) Vězda
Rare; on weathered concrete. Wilhelm #14142 (crustose; saxicolous)

CALOPLACA Th. Fr.

Caloplaca feracissima H. Magn.
Common; on weathered asphalt and concrete with *Endocarpon pusillum* and *Lecanora dispersa.* Horn #20 (crustose; saxicolous)

Caloplaca microphyllina (Tuck.) Hasse
Occasional; on weathered wood rail fences. (crustose; lignicolous)

CANDELARIA A. Massal.

Candelaria concolor (Dickson) Stein
Common; on the trunks and branches of *Acer saccharinum, Crataegus mollis, Fraxinus pennsylvanica* var. *subintegerrima, Quercus rubra, Tilia americana, Ulmus americana,* and *U. rubra,* and on weathered concrete and wood fencing. Horn #12; Wilhelm #14150 (foliose; corticolous/lignicolous/saxicolous)

Candelaria concolor (Dickson) Stein var. *effusa* (Tuck.) G. Merr. & Burnham
Occasional; on the trunks of *Crataegus mollis* and *Ulmus americana.* Wilhelm #14140, #14148 (foliose; corticolous)

CANDELARIELLA Müll. Arg.

Candelariella reflexa (Nyl.) Lettau
Occasional; on the lower branches of *Crataegus mollis* and on weathered wood fences. (crustose; corticolous/lignicolous)

CATAPYRENIUM Flotow

Catapyrenium squamulosum (Ach.) Breuss
Rare; on shallow soil over dolomite. #849 (squamulose; terricolous)

CLADONIA P. Browne

Cladonia cristatella Tuck.
Occasional; on a decorticate log and weathered wood fencing. (fruticose; lignicolous)

Cladonia macilenta Hoffm. var. *bacillaris* (Genth) Schaerer
Occasional; on decorticate logs. (fruticose; lignicolous)

Cladonia ramulosa (With.) J. R. Laundon
Rare; on a decorticate log. (fruticose; lignicolous)

ENDOCARPON Hedwig

Endocarpon pusillum Hedwig
Common; on weathered concrete with *Caloplaca feracissima* and *Lecanora dispersa*. Horn #21; Wilhelm #14141 (crustose; saxicolous)

FLAVOPARMELIA Hale

Flavoparmelia caperata (L.) Hale
Rare; on the lower trunk of *Fraxinus pennsylvanica* var. *subintegerrima*. (foliose; corticolous)

FLAVOPUNCTELIA (Krog) Hale

Flavopunctelia flaventior (Stirton) Hale
Rare; at the base of *Populus deltoides*. (foliose; corticolous)

HYPERPHYSCIA Müll. Arg.

Hyperphyscia adglutinata (Flörke) H. Mayrh. & Poelt
Occasional; on the lower branches of *Populus deltoides* and *Quercus macrocarpa*. Wilhelm #14143 (foliose; corticolous)

LECANORA Ach.

Lecanora dispersa (Pers.) Sommerf.
Common; on weathered asphalt and concrete with *Caloplaca feracissima* and *Endocarpon pusillum*. (crustose; saxicolous)

Lecanora saligna (Schrader) Zahlbr.
Occasional; on weathered wood fences. Wilhelm #14145 (crustose; lignicolous)

Lecanora symmicta (Ach.) Ach.
Occasional; on weathered wood fencing. (crustose; lignicolous)

LEPRARIA Ach.

Lepraria lobificans Nyl.
Occasional; at the base of *Quercus alba*. (crustose; corticolous)

LICHENOTHELIA D. Hawksw.

Lichenothelia sp. *sensu* MOR Herbarium
Occasional; on a granite boulder in a shaded oak woodland. Wilhelm #14138 (crustose; saxicolous)

MYELOCHROA (Asah.) Elix & Hale

Myelochroa aurulenta (Tuck.) Elix & Hale
Rare; on the lower branches of *Crataegus mollis*. (foliose; corticolous)

OPEGRAPHA Ach.

Opegrapha atra Pers.
Occasional; on the trunks of *Ulmus americana* in wooded floodplains. (crustose; corticolous)

PARMELIA Ach.

Parmelia sulcata Taylor
Frequent; on the trunks and branches of *Crataegus mollis* and on weathered wood rail fencing. Horn #1; Wilhelm #14147 (foliose; corticolous/lignicolous)

PHAEOCALICIUM A. F. W. Schmidt

Phaeocalicium polyporaeum (Nyl.) Tibell
Rare; on the polyporous fungus, *Trichaptum biforme*, which was growing on *Prunus serotina*. #1386 (crustose; fungicolous)

PHAEOPHYSCIA Moberg

Phaeophyscia cernohorskyi (Nádv.) Essl.
Occasional; on a weathered wood picnic table. (foliose; lignicolous)

Phaeophyscia ciliata (Hoffm.) Moberg
Rare; on the lower trunk of *Populus deltoides*. (foliose; corticolous)

Phaeophyscia pusilloides (Zahlbr.) Essl.
Common; on weathered concrete, and on the lower branches of *Acer negundo* and *Populus deltoides*. (foliose; corticolous/saxicolous)

Phaeophyscia rubropulchra (Degel.) Essl.
Common; on the lower trunks of *Crataegus mollis*, *Populus deltoides*, and *Quercus rubra*. Wilhelm #14139 (foliose; corticolous)

PHYSCIA (Schreber) Michaux

Physcia adscendens (Fr.) H. Olivier
Occasional; on the lower trunks of *Crataegus mollis* and *Fraxinus pennsylvanica* var. *subintegerrima*. Horn #14 (foliose; corticolous)

Physcia millegrana Degel.
Common; on the trunks and branches of *Acer negundo, A. saccharinum, Crataegus mollis, Gleditsia triacanthos* f. *inermis, Populus deltoides, Quercus macrocarpa*, and *Ulmus rubra*, and on weathered wood fencing. Horn #13 (foliose; corticolous/lignicolous)

Physcia stellaris (L.) Nyl.
Common; on the trunks and branches of *Acer negundo, Crataegus mollis, Fraxinus pennsylvanica* var. *subintegerrima, Gleditsia triacanthos* f. *inermis*, and *Ulmus americana*. Horn #15; Wilhelm #14149 (foliose; corticolous)

PHYSCIELLA Essl.

Physciella chloantha (Ach.) Essl.
Common; on the trunks of *Fraxinus pennsylvanica* var. *subintegerrima, Ulmus americana*, and *U. rubra*, and on weathered concrete. (foliose; corticolous/saxicolous)

PHYSCONIA Poelt

Physconia detersa (Nyl.) Poelt
Rare; on the trunk of *Populus deltoides*. (foliose; corticolous)

PROTOBLASTENIA (Zahlbr.) J. Steiner

Protoblastenia rupestris (Scop.) J. Steiner
Rare; on weathered dolomite. (crustose; saxicolous)

PUNCTELIA Krog

Punctelia rudecta (Ach.) Krog
Rare; on the trunk of *Populus deltoides*. (foliose; corticolous)

RIMELIA Hale & Fletcher

Rimelia reticulata (Taylor) Hale & Fletcher
Rare; on the lower trunk of *Fraxinus pennsylvanica* var. *subintegerrima*. (foliose; corticolous)

SARCOGYNE Flotow

Sarcogyne regularis Körber
Rare; on weathered dolomite. (crustose; saxicolous)

THELOCARPON Nyl. *ex* Hue

Thelocarpon laureri (Flotow) Nyl.
Rare; on a weathered wood rail fence. (crustose; lignicolous)

TRAPELIOPSIS Hertel & Gotth. Schneider

Trapeliopsis flexuosa (Fr.) Coppins & P. James
Occasional; on weathered wood rail fences. (crustose; lignicolous)

VERRUCARIA Schrader

Verrucaria calkinsiana Servít.
Occasional; on weathered concrete. (crustose; saxicolous)

XANTHORIA (Fr.) Th. Fr.

Xanthoria fallax (Hepp) Arnold
Common; on the trunks of *Crataegus mollis, Prunus serotina*, and *Ulmus rubra*, and on weathered wood rail fences. Horn #17 (foliose; corticolous)

SALT CREEK DIVISION LICHEN CHECKLIST

Bemis Woods
(NE S31 T39N R12E and S S31 T39N R12E)
Anisomeridium nyssigenum
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Candelaria concolor var. effusa
Endocarpon pusillum
Lecanora dispersa
Lepraria lobificans
Lichenothelia sp.
Parmelia sulcata
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Physciella chloantha
Xanthoria fallax

Brezina Woods
(N S28 T39N R12E)
Anisomeridium nyssigenum
Caloplaca feracissima
Candelaria concolor
Lecanora dispersa
Opegrapha atra
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris

Brookfield Woods
(SW S26 T39N R12E)
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Candelaria concolor var. effusa
Endocarpon pusillum
Parmelia sulcata
Phaeophyscia cernohorskyi
Physcia adscendens
Physcia millegrana
Physcia stellaris
Xanthoria fallax

Brookfield Zoo
(NW S35 T39N R12E)
Amandinea punctata
Caloplaca feracissima
Candelaria concolor
Lecanora dispersa
Lecanora saligna
Physcia millegrana
Physcia stellaris
Physciella chloantha
Xanthoria fallax

Callahan Grove
(NE S26 T39N R12E)
Amandinea punctata
Caloplaca microphyllina
Candelaria concolor
Candelariella reflexa
Hyperphyscia adglutinata
Lecanora symmicta
Phaeophyscia pusilloides
Physcia millegrana
Physcia stellaris
Xanthoria fallax

Cermak Woods
(NE S1 T38N R12E)
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Phaeophyscia pusilloides
Physcia millegrana
Physciella chloantha
Xanthoria fallax

Chicago Portage
(NE S12 T38N R12E)
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Physcia millegrana
Verrucaria calkinsiana

LaGrange Park Woods
(NW S33 T39N R12E)
Amandinea punctata
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Lecanora saligna
Lepraria lobificans
Phaeophyscia rubropulchra
Physcia millegrana
Xanthoria fallax

McCormick Woods
(SE S26 T39N R12E)
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Hyperphyscia adglutinata
Lecanora dispersa
Phaeophyscia rubropulchra
Physcia millegrana

Meadowlark Golf Course
(NW S31 T39N R12E)
Anisomeridium nyssigenum
Caloplaca feracissima
Candelaria concolor
Lecanora dispersa
Parmelia sulcata
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia adscendens
Physcia millegrana
Physcia stellaris
Physciella chloantha
Xanthoria fallax

Miller Meadow
(E S23 T39N R12E)
Amandinea punctata
Caloplaca feracissima
Candelaria concolor
Flavoparmelia caperata
Hyperphyscia adglutinata
Lecanora dispersa
Phaeophyscia pusilloides
Physcia adscendens
Physcia millegrana
Physcia stellaris
Physciella chloantha
Rimelia reticulata
Thelocarpon laureri
Trapeliopsis flexuosa
Xanthoria fallax

National Grove
(SE S26 T39N R12E)
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris

Ottawa Trail Woods
(E S1 T38N R12E)
Anisomeridium nyssigenum
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia millegrana
Physciella chloantha

Plank Road Meadow
(NE S2 T38N R12E)
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Hyperphyscia adglutinata
Lecanora dispersa
Phaeophyscia pusilloides
Physcia millegrana
Physcia stellaris
Xanthoria fallax

Possum Hollow Woods
(W S29 T39N R12E and
SE S29 T39N R12E)
Amandinea punctata
Anisomeridium nyssigenum
Caloplaca feracissima
Caloplaca microphyllina
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Lepraria lobificans
Phaeophyscia rubropulchra
Physcia millegrana

Salt Creek Woods Nature Preserve
(N S32 T39N R12E)
Amandinea punctata
Arthonia caesia
Candelaria concolor
Cladonia cristatella
Cladonia ramulosa
Lecanora saligna
Lecanora symmicta
Myelochroa aurulenta
Parmelia sulcata
Physcia millegrana
Physcia stellaris
Trapeliopsis flexuosa

Schuth's Grove
(SE S23 T39N R12E)
Caloplaca feracissima
Candelaria concolor
Candelaria concolor var. effusa
Lecanora dispersa
Phaeophyscia pusilloides
Physcia millegrana
Physcia stellaris
Physciella chloantha

<u>Stony Ford</u>
(SE S1 T38N R12E)
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Lecanora dispersa
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Physciella chloantha

<u>Sundown Meadow/Arie Crown Forest</u>
(W S21 T38N R12E)
Amandinea punctata
Caloplaca feracissima
Caloplaca microphyllina
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Parmelia sulcata
Phaeophyscia pusilloides
Physcia adscendens
Physcia millegrana
Physciella chloantha
Trapeliopsis flexuosa

<u>Theodore Stone Forest</u>
(NE S21 T38N R12E)
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Catapyrenium squamulosum
Endocarpon pusillum
Lecanora dispersa
Opegrapha atra
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Physciella chloantha
Protoblastenia rupestris
Sarcogyne regularis
Verrucaria calkinsiana
Xanthoria fallax

<u>Twenty-Sixth Street Woods</u>
(N S27 T39N R12E)
Caloplaca feracissima
Candelaria concolor
Candelariella reflexa
Endocarpon pusillum
Lecanora dispersa
Opegrapha atra
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Physciella chloantha
Xanthoria fallax

<u>Westchester Woods</u>
(N S28 T39N R12E)
Caloplaca feracissima
Candelaria concolor
Hyperphyscia adglutinata
Lecanora dispersa
Opegrapha atra
Phaeophyscia pusilloides
Physcia millegrana
Physcia stellaris
Xanthoria fallax

<u>White Eagle Woods</u>
(NE S1 T38N R12E)
Caloplaca feracissima
Candelaria concolor
Lecanora dispersa
Phaeophyscia pusilloides
Physcia millegrana
Physciella chloantha

<u>Wolf Road Prairie Nature Preserve</u>
(SE S30 T39N R12E)
Amandinea punctata
Arthonia caesia
Bacidia granosa
Bacidina egenula
Caloplaca feracissima
Candelaria concolor
Candelaria concolor var. effusa
Cladonia cristatella
Cladonia macilenta var. bacillaris
Endocarpon pusillum
Flavopunctelia flaventior
Hyperphyscia adglutinata
Lecanora dispersa
Lecanora symmicta
Parmelia sulcata
Phaeocalicium polyporaeum
Phaeophyscia cernohorskyi
Phaeophyscia ciliata
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia adscendens
Physcia millegrana
Physcia stellaris
Physciella chloantha
Physconia detersa
Punctelia rudecta
Trapeliopsis flexuosa
Verrucaria calkinsiana
Xanthoria fallax

<u>Zoo Woods</u>
(NW S35 T39N R12E)
Arthonia caesia
Caloplaca feracissima
Candelaria concolor
Endocarpon pusillum
Lecanora dispersa
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris

Acknowledgments

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ERIGENIA, Number 17, May 1999, pp. 21–25

THE LICHEN FLORA OF FORD COUNTY, ILLINOIS

Richard D. Hyerczyk[1]

ABSTRACT: Forty-two taxa of lichenized fungi (41 species and one variety) in 25 genera are reported for Ford County, Illinois. Twenty-one are of the foliose growth form, 20 are crustose, and one is fruticose. An annotated species list and information on the distribution and habitats for each taxon are provided. Although none of these represents a new addition to the lichen flora of Illinois, only one taxon was previously reported for Ford County.

INTRODUCTION

Ford County is located in the northern part of central Illinois, approximately 160 km (100 miles) south-southwest of the city of Chicago (fig. 1). It has an area of 125,900 ha (311,000 acres), with nearly 96% of the county lands devoted to agriculture. According to Schwegman (1973), the entire county lies in the Grand Prairie Section of the Grand Prairie Division of the natural divisions of Illinois. Topography is flat to gently rolling with elevations above mean sea level ranging from 200 meters (656 feet) in the northern part of the county to 250 meters (820 feet) in the southern part.

Ford County has a temperate climate, with January temperatures averaging −0.85° C (30.5° F) maximum and −10.2° C (13.7° F) minimum. July temperatures average 30.3° C (86.4° F) maximum and 17.2° C (62.9° F) minimum. About 90.2 cm (35.5 inches) of precipitation fall in one year, including 67.3 cm (26.5 inches) of snow.

Ladd and Wilhelm (1998) reported one taxon from Ford County. Hyerczyk (1997) reported 61 taxa from adjacent Livingston County. Nothing else, however, could be found in the literature on Ford County lichens. Since no other studies of the lichen flora of Ford County are known, this paper was written to document and provide information on the distribution and habits of these lichenized fungi.

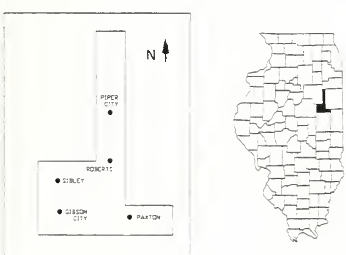

Fig. 1. Ford County, Illinois

MATERIALS AND METHODS

Cemeteries and lands bordering railroad lines, as well as populated areas, were the main collecting sites; plowed farmlands were excluded. In addition, two privately owned preserves and one Illinois nature preserve were surveyed. Specimens were identified using keys by Hale (1979) and Wilhelm (1998), and have been deposited at the Morton Arboretum herbarium (MOR), Lisle, Illinois. Specimens previously collected by others, and housed at MOR, were also included in this paper. Nomenclature approximates Esslinger and Egan (1995).

RESULTS

Forty-two taxa of lichens (41 species and one variety) in 25 genera are reported for Ford County, Illinois (Appendix 1). Twenty-one are of the foliose growth form, 20 are crustose, and one is fruticose. Nearly 62% were found on corticolous substrates, including (in decreasing order of importance) *Quercus macrocarpa*, *Q. velutina*, *Acer saccharum*, *Gleditsia triacanthos*, *Juglans nigra*, *Fraxinus americana*, and *F. pennsylvanica* var. *subintegerrima*. Of the remainder, 24% were saxicolous (on weathered concrete, and on dolomite or marble headstones), 12% were lignicolous (on weathered wood fencing or railroad ties), and 2% were fungicolous (on the polyporous fungus *Trichaptum biforme*).

Land uses in Ford County are similar to those in Livingston County; these counties devote an average of 97% of their lands to farming and agriculture, with very little remaining in the way of natural areas. Nearly 80% of the taxa reported for Ford County were also found in Livingston County (Hyerczyk 1997). Taxa reported from Ford County but absent from Livingston County include *Caloplaca ulmorum*, *Candelariella vitellina*, *Flavopunctelia*

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flaventior, Lecanora symmicta, L. umbrina, Parmelia sulcata, Parmotrema hypotropum, Phaeocalicium polyporaeum, and *Trapeliopsis flexuosa.*

Hale's (1979) range maps exclude nearly 40% of the macrolichens (foliose and fruticose) currently known from Ford County. Crustose lichens are not included in Hale (1979).

Sixteen taxa of lichens in 13 genera are reported from the Bur Oak Grove (S35 and S36 T25N R7E), a 38-acre presettlement bur oak grove owned by the Nature Conservancy near Sibley (Appendix 2). Nearly all of the taxa reported were found on *Quercus macrocarpa,* with a few on *Crataegus mollis, Prunus serotina,* and *Juglans nigra;* one was fungicolous. Ten taxa were foliose and 6 were crustose.

Nineteen taxa of lichens in 13 genera are reported from Prospect Cemetery Nature Preserve (S17 T23N R10E), a 5-acre cemetery with a remnant mesic black soil prairie, near Paxton (Appendix 3). The majority of the lichens were found on *Quercus velutina* and a few on marble or dolomite headstones. Thirteen species were foliose and 7 were crustose. Nearly 65% were found on corticolous substrates, 30% were saxicolous, and 5% were lignicolous.

Twenty-three taxa of lichens (22 species and one variety) in 16 genera are reported from Howard Thomas Memorial Woods (S14 T23N R9E), a presettlement oak grove near Paxton (Appendix 4). Fourteen taxa were foliose and 9 were crustose. Nearly 66% were found on corticolous substrates, 21% were saxicolous, and 13% were lignicolous.

ACKNOWLEDGMENTS

I would like to thank Dr. Gerould Wilhelm from Conservation Design Forum, Inc., Elmhurst, Illinois, for his assistance in identification and verification of specimens; also thanks to James P. McMahon, Central Illinois Area Director, The Nature Conservancy; The Grand Prairie Friends of Illinois; Don Gardner; and Lisa Bell for all their help in this project.

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APPENDIX 1

An alphabetized, annotated list of the lichenized fungi reported follows. Names used by Hale (1979) are included as synonyms where appropriate. A brief discussion of habitat is followed by the growth form and substrate(s) of each taxon. Collectors are indicated as follows: W&W = Wilhelm & Wetstein, W&S = Wilhelm & Shimp, W = Wilhelm, H = Hyerczyk.

ANISOMERIDIUM (Müll. Arg.) Choisy

Anisomeridium nyssigenum (Ellis & Everh.) R. C. Harris
Near Paxton on *Ulmus americana* (H #1442); also on *Quercus alba* and *Q. macrocarpa.* (crustose, corticolous)

ARTHONIA Ach.

Arthonia caesia (Flotow) Körber
Near Sibley, on *Quercus palustris* (W&S #17564); also on *Quercus macrocarpa.* (crustose; corticolous)

CALOPLACA Th. Fr.

Caloplaca feracissima H. Magn.
Near Piper City, on limestone railroad ballast (H #1059); also on weathered concrete. (crustose; saxicolous).

Caloplaca holocarpa (Hoffm. ex Ach.) M. Wade
Near Piper City, on a weathered railroad tie (H #1063); also on the exposed root of *Acer saccharum.* (crustose; lignicolous)

Caloplaca microphyllina (Tuck.) Hasse
Near Piper City, on a weathered wood fence post (H #1055); also on *Quercus macrocarpa.* (crustose; corticolous/lignicolous)

Caloplaca ulmorum (Fink) Fink
Near Paxton at Prospect Cemetery Nature Preserve on a weathered dolomite headstone (H #1440). (crustose; saxicolous)

CANDELARIA A. Massal.

Candelaria concolor (Dickson) Stein

Near Sibley, on *Ulmus americana* (W&S #17567); also on weathered concrete and wood and on *Carya ovata, Fraxinus americana, Juglans nigra,* and *Quercus macrocarpa*. (foliose; corticolous/lignicolous/saxicolous)

Candelaria concolor var. *effusa* (Tuck.) G. Merr. & Burnham

Near Sibley, on *Fraxinus pennsylvanica* var. *subintegerrima* (W&S #17575); also on *Acer saccharum*. (foliose; corticolous)

CANDELARIELLA Müll. Arg.

Candelariella vitellina (Hoffm.) Müll. Arg.

Near Sibley, on *Gleditsia triacanthos* (W #17571). (crustose; corticolous)

Candelariella xanthostigma (Ach.) Lettau

Near Paxton, on *Quercus rubra* (H #1085); also on *Acer saccharum, Juglans nigra, Quercus alba, Q. macrocarpa,* and *Q. velutina*. (crustose; corticolous)

CLADONIA P. Browne

Cladonia coniocraea (Flörke) Sprengel

Near Roberts, on *Quercus marcocarpa* (H #1072). (fruticose; corticolous)

CYPHELIUM Ach.

Cyphelium tigillare (Ach.) Ach.

Near Piper City, on a wood rail fence (H #1053). (crustose; lignicolous)

ENDOCARPON Hedwig

Endocarpon pusillum Hedwig

Near Piper City, on pebbles and limestone railroad ballast (H #1058); also on weathered concrete and dolomite. (crustose; saxicolous)

FLAVOPARMELIA Hale

Flavoparmelia caperata (L.) Hale = *Pseudoparmelia caperata* (L.) Hale

Near Gibson City, on *Quercus palustris* (W&W #20124); also on *Quercus velutina*. (foliose; corticolous)

FLAVOPUNCTELIA (Krog) Hale

Flavopunctelia flaventior (Stirton) Hale = *Parmelia flaventior* Stirt.

Near Sibley, on *Gleditsia triacanthos* (W&S #17568). (foliose; corticolous)

Flavopunctelia soredica (Nyl.) Hale = *Parmelia ulophylloides* (Vain.) Sav.

Near Paxton, at the Prospect Cemetery Nature Preserve, on *Quercus velutina* (H #1439). (foliose; corticolous)

GRAPHIS Adans.

Graphis scripta (L.) Ach.

Near Roberts, on *Carya ovata* (H #1071); near Paxton, on *Quercus rubra* (H #1084). Also on *Quercus alba* and *Q. velutina*. (crustose; corticolous)

HYPERPHYSCIA Müll. Arg.

Hyperphyscia adglutinata (Flörke) Mayrh. & Poelt = *Physciopsis adglutinata* (Flk.) Choisy

Near Sibley, on *Fraxinus pennsylvanica* var. *subintegerrima* (W&S #17572); also on *Juglans nigra* and *Ulmus americana*. (foliose; corticolous)

LECANORA Ach.

Lecanora dispersa (Pers.) Sommerf.

Near Sibley on railroad ballast (H #1438); also on weathered concrete and dolomite. (crustose; saxicolous)

Lecanora strobilina (Sprengel) Kieffer

Near Roberts, on *Carya ovata* (H #1074). (crustose; corticolous)

Lecanora symmicta (Ach.) Ach.

Near Sibley, on *Quercus palustris* (W&S #17565). (crustose; corticolous)

Lecanora umbrina (Ach.) A. Massal.

Near Piper City, on a weathered railroad tie (H #1062); near Piper City, again on a weathered railroad tie (H #1064). (crustose; lignicolous)

LEPRARIA Ach.

Lepraria lobificans Nyl.

Near Paxton, on *Quercus rubra* (H #1083); also on *Quercus macrocarpa* and *Q. velutina*. (crustose; corticolous)

OPEGRAPHA Ach.

Opegrapha atra Pers.

Near Paxton, at the Howard Thomas Memorial Woods, on the trunk of *Ulmus americana* (H #1595). (crustose; corticolous)

PARMELIA Ach.

Parmelia sulcata Taylor

Near Sibley, on *Gleditsia triacanthos* (W&S #17569). (foliose; corticolous)

PARMOTREMA A. Massal.

Parmotrema hypotropum (Nyl.) Hale

Near Paxton, at the Howard Thomas Memorial Woods, on a dead tree (H #1589). (foliose; corticolous)

PERTUSARIA DC.

Pertusaria pustulata (Ach.) Duby

Near Roberts, on *Carya ovata* (H #1075). This species was first reported by Ladd and Wilhelm (1998). (crustose; corticolous)

PHAEOCALICIUM A. F. W. Schmidt

Phaeocalicium polyporaeum (Nyl.) Tibell

Near Sibley, at the Bur Oak Grove, on the polyporous fungus, *Trichaptum biforme,* which was growing on *Prunus serotina* (H #1601). (crustose; fungicolous)

PHAEOPHYSCIA Moberg

Phaeophyscia cernohorskyi (Nádv.) Essl.

Near Roberts, on granite headstones in a cemetery (H #1080); also on weathered concrete and dolomite. (foliose; saxicolous)

Phaeophyscia ciliata (Hoffm.) Moberg
Near Roberts, on marble headstones in a cemetery (H #1070); also on *Carya ovata* and on weathered concrete and dolomite. (foliose; corticolous/saxicolous)

Phaeophyscia pusilloides (Zahlbr.) Essl.
Near Piper City, on marble headstones in a cemetery (H #1057); near Roberts, on marble headstones in a cemetery (H #1069). (foliose; saxicolous)

Phaeophyscia rubropulchra (Degel.) Essl.
Near Roberts, on *Quercus macrocarpa* (H #1066); also on the lower trunks of *Crataegus mollis, Fraxinus americana, Quercus alba,* and *Q. macrocarpa*. (foliose; corticolous)

PHYSCIA (Schreber) Michaux

Physcia adscendens (Fr.) H. Olivier
Near Roberts, on granite headstones in a cemetery (H #1068). (foliose; saxicolous)

Physcia millegrana Degel.
Near Sibley, on *Quercus palustris*. (W&S #17566); also on weathered wood fencing and on *Acer saccharum, Crataegus mollis, Fraxinus americana, Juglans nigra, Prunus serotina, Quercus alba,* and *Q. macrocarpa*. (foliose; corticolous/lignicolous)

Physcia stellaris (L.) Nyl.
Near Sibley, on *Fraxinus pennsylvanica* var. *subintegerrima* (W&S #17574); also on *Quercus macrocarpa*. (foliose; corticolous)

PHYSCONIA Poelt

Physconia detersa (Nyl.) Poelt
Near Roberts, on weathered concrete (H #1081). (foliose; saxicolous)

PUNCTELIA Krog

Punctelia bolliana (Müll. Arg.) Krog
Near Roberts, on *Carya ovata* (H #1077); near Gibson City, on *Quercus palustris* (W&W #20123). (foliose; corticolous)

Punctelia missouriensis Wilhelm & Ladd
Near Paxton, at the Howard Thomas Memorial Woods, on the trunk of *Quercus rubra* (H #1589). (foliose; corticolous)

Punctelia rudecta (Ach.) Krog
Near Roberts, on *Quercus macrocarpa* (H #1076); near Paxton, on *Quercus rubra* (H #1082). (foliose; corticolous)

TRAPELIOPSIS Hertel & Gotth. Schneider

Trapeliopsis flexuosa (Fr.) Coppins & P. James
Near Paxton, on a weathered telephone pole (H #1482). (crustose; lignicolous)

XANTHORIA (Fr.) Th. Fr.

Xanthoria fallax (Hepp) Arnold
Near Sibley, on *Fraxinus pennsylvanica* var. *subintegerrima* (W&S #17573). (foliose; corticolous)

Xanthoria sp. #1, *sensu* MOR
Near Roberts, on a limestone tombstone in a cemetery (H #1067). (foliose; saxicolous)

APPENDIX 2: Bur Oak Grove

Anisomeridium nyssigenum
Arthonia caesia
Caloplaca microphyllina
Candelaria concolor
Candelariella xanthostigma
Hyperphyscia adglutinata
Lepraria lobificans
Parmelia sulcata
Phaeocalicium polyporaeum
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Punctelia bolliana
Punctelia missouriensis
Punctelia rudecta
Xanthoria sp. #1

APPENDIX 3: Prospect Cemetery Nature Preserve

Arthonia caesia
Caloplaca ulmorum
Candelaria concolor
Candelariella xanthostigma
Endocarpon pusillum
Flavoparmelia caperata
Flavopunctelia flaventior
Flavopunctelia soredica
Lecanora dispersa
Lecanora symmicta
Lecanora umbrina
Parmelia sulcata
Phaeophyscia cernohorskyi
Phaeophyscia ciliata
Phaeophyscia rubropulchra
Physcia millegrana
Physcia stellaris
Punctelia bolliana
Xanthoria sp. #1

APPENDIX 4: Howard Thomas Memorial Woods

Anisomeridium nyssigenum
Caloplaca feracissima
Caloplaca holocarpa
Candelaria concolor
Candelaria concolor var. effusa
Candelariella xanthostigma
Endocarpon pusillum
Flavoparmelia caperata
Graphis scripta
Hyperphyscia adglutinata
Lecanora dispersa

Lepraria lobificans
Opegrapha atra
Parmotrema hypotropum
Phaeophyscia cernohorskyi
Phaeophyscia ciliata
Phaeophyscia rubropulchra
Physcia millegrana
Punctelia bolliana
Punctelia missouriensis
Punctelia rudecta
Xanthoria fallax
Xanthoria sp. #1

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Vegetation of Badger *(Taxidea taxus)* and Plains Pocket Gopher *(Geomys bursarius)* Mounds in the Sand Areas of West-Central Illinois

Bradley A. Fulk[1] and John E. Ebinger[2]

ABSTRACT: Plant species richness on badger and pocket gopher mounds was studied at the Henry Allan Gleason Nature Preserve, Mason County, Illinois. Within the sand prairie at the preserve, 27 species were found on badger mounds, 24 on pocket gopher mounds, and 21 on adjacent areas without mounds, resulting in 1.31, 1.21, and 1.23 diversity index values, respectively. The mean area of a badger mound (2.57 m^2) was significantly greater than a pocket gopher mound (0.39 m^2).

Introduction

The American badger *(Taxidea taxus)* and the plains pocket gopher *(Geomys bursarius)* are common species in the sand prairies near Havana, Mason County, Illinois (Hoffmeister 1989). Badger burrows are excavated for dens and in the quest for prey (Errington 1937; Lampe 1982). These excavations leave considerable volumes of disturbed soil, forming 2–3 m^2 mounds (Platt 1975). Plains pocket gophers, in contrast, create smaller mounds, mostly less than 0.5 m^2, which are formed during tunnel construction while foraging (Gibson 1989; Grant, French, and Folse 1980).

The impact on vegetation is significant where pocket gophers and badgers are abundant (Reichman and Smith 1985). In areas occupied by badgers, burrows are more abundant in dry areas on slopes or along hilltops (Platt 1975). Disturbances by pocket gophers are located in areas of high vegetation densities (Grant, French, and Folse 1980). These disturbances have been viewed as uncommon, irregular events that cause abrupt structural changes in a plant community (Sousa 1984).

Disturbances due to mound formation appear to play a significant role in shaping the structure of plant communities, although the impact on species richness depends largely on the nature of the dominant plants, the rate of succession, and seasonal changes (Armesto and Pickett 1985). The objective of this study was to determine the plant species composition on badger and pocket gopher mounds on a sand prairie remnant in Mason County, Illinois.

Location of Study Site

The study site is located in the Illinois River Section of the Illinois and Mississippi Rivers Sand Areas Natural Division (Schwegman 1973). This section is characterized by sandy soil, known as the Parkland Sand, that was deposited during the melting of the Wisconsinan glacier and later reworked by wind (Willman and Frye 1970). All study plots were located within a 30 ha field on the southern half of the Henry Allan Gleason Nature Preserve (SE S6 and NE S7 T22N R7W). In this field is reestablished sand prairie vegetation that still contains many successional species. Prior to dedication as a nature preserve in 1970, this field was cultivated. Management practices include prescribed burning and the cutting of trees and exotic shrubs (McFall and Karnes 1995).

Methods

During February and March of 1991, the site was searched for badger and pocket gopher mounds that had been excavated after the growing season of 1990. Each badger mound was marked with a survey flag and plotted. Areas having high pocket gopher mound densities were marked by placing 4 flags in a square around 10 to 20 mounds.

In late June the study site was surveyed to determine plant species composition, dominant species, and total plant cover on the badger and pocket gopher mounds and on adjacent areas undisturbed by burrowing activity. A 0.25 m^2 circular plot was employed. The plots were placed near the center of each mound, and in the areas adjacent to the mounds, they were placed randomly. All

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badger mounds found were sampled; in the case of pocket gopher mounds, each square marked earlier in the year represented a sample area. Within each area, 4 to 7 pocket gopher mounds were randomly selected for sampling. Adjacent to each pocket gopher sampling area, 4 plots were sampled in vegetation that lacked mounds. On the prairie, 12 plots on badger mounds, 28 plots on pocket gopher mounds, and 16 plots adjacent to the mounds were sampled. Percent total plant cover was estimated for each plot using the 6 classes described by Daubenmire (1959): 1 = 0–5%, 2 = 5–25%, 3 = 25–50%, 4 = 50–75%, 5 = 75–95%, 6 = 95–100%, and the percent frequency of occurrence was calculated for each species sampled on each site. The plant species with the highest cover was considered the dominant on the plot. The Shannon-Wiener measurement (Krebs 1972) was used to compare species diversity. Plant nomenclature follows Mohlenbrock (1986).

RESULTS

The most frequent species found on badger mounds were *Cassia fasciculata* (58.3%), *Commelina erecta* (50.0%), *Opuntia humifusa* (50.0%), *Ambrosia psilostachya* (41.0%), and *Aristida tuberculosa* (41.0%). *Cassia fasciculata* (71.4%), *Opuntia humifusa* (66.7%), *Conyza canadensis* (57.1%), and *Lepidium virginicum* (57.1%) were the most important on pocket gopher mounds (table 1). In most instances, individuals of *Opuntia humifusa* had grown through the mounds from specimens covered when the mounds were excavated. In the adjacent areas that lack mounds, the most frequent species were *Conyza canadensis* (75.0%), *Opuntia humifusa* (56.3%), *Paspalum bushii* (56.3%), *Cassia fasciculata* (43.8%), and *Ambrosia psilostachya, Bouteloua hirsuta, Diodia teres,* and *Leptoloma cognatum* (each at 37.5%). Mean cover was nearly equal on badger (36% cover) and pocket gopher mounds (35% cover), and was 88% on the adjacent plots that lacked mounds. Also, badger mounds had a higher diversity index (1.31) than pocket gopher mounds (1.21) and the adjacent areas that lacked mounds (1.23).

Badger mounds averaged 6.5 times larger than pocket gopher mounds. The mean area covered by badger mounds ($n = 12$, $\overline{X} = 2.57\ m^2$, SE = 5,130.06) and pocket gopher mounds ($n = 25$, $\overline{X} = 0.39\ m^2$, SE = 338.05) were significantly different ($t = -5.903$, $P < 0.001$).

DISCUSSION

Vegetation responses to disturbance depend on the physical nature of the disturbance, the vegetational composition of the community, and the rate, intensity, and duration of disturbance. Both badger and pocket gopher activity created openings for colonizing species and opportunities for increased plant species richness. In the sand prairie 27 species were identified on badger mounds and 24 species on pocket gopher mounds, compared with 21 species in the adjacent areas lacking mounds (table 1).

These disturbances ensure the presence of "colonizer" species on the study sites. Species recognized as competitors are typically dominants of later seral stages that will occupy disturbed sites via dispersal and growth of propagules as microclimatic variation decreases (Platt and Weis 1977). Colonizing species, in contrast, are characterized by high rates of reproduction, widely dispersed propagules, and the ability to thrive on disturbance sites where microclimatic factors are less stable. Studies suggest that species diversity is maximized at intermediate levels of disturbance within communities (Abugov 1982; Miller 1982; Sousa 1984). If disturbance rates are maintained at low levels, or are absent completely, competitive species may eliminate colonizing species through growth and dispersal. If disturbance rates are high, colonizing species with high growth and reproductive capabilities may persist through rapid colonization, while competitive dominants are excluded (Miller 1982).

In general, the animal mounds support an increased diversity of species compared with plots lacking mounds. Also, the number of dominant plant species showed an increase from 4 in adjacent areas lacking mounds to 8 on pocket gopher mounds, and to 7 on badger mounds (table 1). Many of the colonizer plants of the mounds were also common species throughout the sand prairie. Although most were annuals, some perennial species were associated with mound disturbances. Some of these had low frequencies *(Dichanthelium villosissimum, Eragrostis trichodes, Monarda punctata, Solanum carolinense,* and *Tradescantia ohiensis),* while some were extremely common mound components *(Agrostis hyemalis, Bouteloua hirsuta, Commelina erecta, Opuntia humifusa,* and *Paspalum bushii).* Most of these perennials, particularly *Opuntia humifusa,* were regrowths of individuals covered during mound excavation. The perennial *Commelina erecta* was more common on disturbance mounds, probably because of decreased competition. In contrast, 9 annual and biennial species were recorded for the mounds, but were not found in the adjacent plots lacking mounds (table 1). These species were found in other disturbed areas, such as blowouts, but were not present in the area studied. It appears that the intermediate levels of disturbance allow both perennial and successional annual species to recolonize the disturbed areas but prevent dominance by one or a few of them. This results in a nonequilibrium state with high species richness (Sousa 1984). Burrowing activity by mammals is causing continuous disturbance, resulting in various successional stages and increased plant species diversity.

Table 1. Frequency, dominance, diversity index, mean cover, and total species present on badger and pocket gopher mounds and in undisturbed habitat of a sand prairie at the Henry Allan Gleason Prairie Nature Preserve

Species	Badger (n=12) freq./dom.	Pocket gopher (n=28) freq./dom.	Adjacent areas (n=16) freq./dom.
Agrostis hyemalis *	——	28.6 / 4	——
Ambrosia artemisiifolia	16.7 / 1	21.4 / 1	12.5 / –
Ambrosia psilostachya *	41.0 / –	14.3 / –	37.5 / –
Aristida desmantha	8.3 / –	14.3 / –	25.0 / 4
Aristida tuberculosa	41.0 / –	17.9 / –	——
Bouteloua hirsuta *	16.7 / –	17.9 / 1	37.5 / 5
Bromus tectorum +	25.0 / –	——	——
Cassia fasciculata	58.3 / 3	71.4 / 9	43.8 / –
Cenchrus longispinus	——	3.6 / –	——
Chenopodium album	8.3 / –	10.7 / 1	——
Commelina erecta *	50.0 / 1	39.3 / –	12.5 / –
Conyza canadensis	16.7 / –	57.1 / 1	75.0 / –
Croton glandulosus	33.3 / –	32.1 / –	18.8 / –
Cycloloma atriplicifolium	8.3 / –	——	——
Cyperus filiculmis *	——	17.9 / –	12.5 / –
Dichanthelium villosissimum	8.3 / –	——	6.3 / –
Diodia teres	8.3 / 1	32.1 / 6	37.5 / –
Eragrostis trichodes *	8.3 / –	——	——
Froelichia floridana	8.3 / –	21.4 / –	——
Gnaphalium obtusifolium	——	——	12.5 / –
Helianthus petiolaris +	8.3 / 1	3.6 / –	——
Heterotheca camporum *	——	——	25.0 / –
Ipomoea hederacea +	8.3 / –	——	——
Lepidium virginicum	33.3 / –	57.1 / –	31.3 / –
Leptoloma cognatum *	——	——	37.5 / 5
Monarda punctata *	——	3.6 / –	12.5 / –
Oenothera rhombipetala	8.3 / –	7.1 / –	——
Opuntia humifusa *	50.0 / 2	66.7 / 4	56.3 / 1
Paspalum bushii *	16.7 / –	39.3 / –	56.3 / –
Plantago pusilla	8.3 / –	7.1 / –	25.0 / –
Poinsettia dentata	16.7 / 1	35.7 / –	6.3 / –
Solanum carolinense * +	8.3 / –	——	——
Strophostyles helvola	16.7 / –	14.3 / –	12.5 / –
Tradescantia ohiensis *	8.3 / –	——	——
Diversity Index	1.31	1.21	1.23
Mean Cover Class (% cover)	2.92 (36%)	2.86 (35%)	5.38 (88%)
Total Species	27	24	21

*perennial, +adventive

Note: Dominance number indicates the number of times a species was the obvious dominant taxon in a plot.

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Restoration of Aspects of Native Soil Quality Through Conversion of Agricultural Lands to Cultivated Hayfields

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ABSTRACT: In the Midwestern United States, degraded agricultural lands are often cultivated as hayfields. This practice reduces soil erosion and improves soil quality, though such improvements can be modest compared with the original condition before row crop production. We compared several physical, biological, and chemical properties of soils underlying 3 mesic tallgrass prairie sites and 3 long-term (7 to 25 years) cultivated hayfields in central Illinois to determine the degree to which converting degraded agricultural lands into hayfields restores soil quality. We found that soils underlying cultivated hayfields were more compacted and had lower organic matter content levels, cation exchange capacities, and water-holding capacities than prairie soils. Soil aggregate structure and nutrient contents were similar in cultivated hayfield and prairie soils. Thus, hayfield cultivation can restore some, but not all, aspects of soil health. Programs that promote soil conservation and restoration by encouraging hayfield plantings may not adequately lead to key improvements in soil health.

Introduction

Throughout the Midwestern United States, there are a great number of acres of agricultural land that have been in continuous or near-continuous cultivation in major cash crops since the mid 1800s. Long-term cultivation results in depleted levels of organic matter in soils, a result of removing more of the primary production from a plot of land than is returned (Buyanovsky, Kucera, and Wagner 1987; Beauchamp and Voroney 1994; Eghball et al. 1994; Dodds et al. 1996; Paul et al. 1997). Soils depleted of organic matter have greater bulk densities and are more easily compacted, have reduced soil aggregate structure and increased erodibility, and have reduced water, air, and nutrient-holding capacities (Kohnke 1968; Weaver 1968; Elliott 1986; Jastrow 1987; Stern 1991; Cihacek and Swan 1994; Hudson 1994; Loch and Pocknee 1995; Lowery et al. 1995; Dodds et al. 1996; Rao, Singh, and Gupta 1997). Further, the composition and activity of key soil microbial communities often change dramatically, altering mineralization rates and the availability of various macronutrients (Farrell et al. 1994; Dodds et al. 1996; Rao, Singh, and Gupta 1997; Sotomayor and Rice 1996). Recent research has focused on developing agricultural practices that reduce soil erosion and provide sustainable soil health by maintaining soil organic matter content and aggregate structure (Reicosky et al. 1995; Warkentin 1995; Wolkomir 1995).

One method for restoring the health of degraded agricultural soils is to put the land into use as cultivated pastureland or hayfield (Lee 1996). Putting degraded agricultural lands into cultivated grasses, either for grazing or for commercial haying, reduces soil erosion and improves soil quality, while providing the farmer with some economic return (Rao, Singh, and Gupta 1997). In 1980, and again in 1995, Illinois passed legislation to provide funding for a variety of programs that promote the development and use of sustainable agricultural practices to preserve the long-term productivity of Illinois soils. Under that legislation, pastureland and hayfield plantings are eligible for cost-sharing on an estimated 2–3 million acres of farmland throughout the state (Illinois Department of Agriculture 1995, 1996). These programs are likely to become more popular than set-aside programs that preclude any commercial use of set-aside acres (e.g., the Conservation Reserve Program, established by federal legislation in the 1985 Food Security Act, which had enrolled a total of 35.4 million acres within the first 6 years [Zobeck et al. 1995]). Improvements in the quality of soils underlying cultivated grasslands can be modest, however, even when the grasses are not baled off or grazed (Dormaar et al. 1995; Zobeck et al. 1995), and such alternative agricultural uses can present an economic burden, particularly to smaller-scale individual farmers, who often can afford only marginally arable lands to begin with (Tweeten 1995). The efficacy of state-wide legislative programs that encourage pastureland and hayfield plantings depends on the degree to which soil health can be restored by converting degraded cropland into

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pastureland or hayfield. Unfortunately, there is at present little data available on soil quality improvements associated with these programs.

Here we present data on several physical and chemical properties of soils underlying mesic tallgrass prairie sites and cultivated hayfields in central Illinois. Specifically, we examined the degree to which converting degraded agricultural lands into hayfields restores soil quality to levels seen in uncultivated soils. We compared several physical and chemical properties of soils underlying 3 mesic tallgrass prairie sites and 3 cultivated hayfields in central Illinois. Soil parameters measured were chosen to reflect a wide range of attributes strongly related to soil health (Romig et al. 1995), including soil compaction; aggregate structure; organic matter content; pH; cation exchange capacity; free nitrate, phosphate, and cation contents; and water-holding capacity.

MATERIALS AND METHODS

Site Descriptions and Cultivation Histories

We selected 3 local mesic tallgrass prairie sites and 3 cultivated legume hayfield sites. A descriptive summary of these sites is presented in table 1. All sites were within the published range of the former tallgrass prairie: 4 sites were located in the Galesburg Section of the Western Forest-Prairie Division, and 2 (Brucker plot and Root plot) were located in the Grand Prairie Section of the Grand Prairie Division (McClain 1997). All sites were located within a 27 km radius, in Peoria (5 sites) and Marshall (Root plot) counties in Illinois. Care was taken to ensure that the underlying soils were as similar as possible and were representative of agricultural fields in the Peoria County area. Soil type determinations were obtained from published soil maps (Walker 1992; Marshall-Putnam Soil and Water Conservation District). Four of the sites (2 prairie and 2 hayfield) were located on predominantly Rozetta Silt Loam (1–5% slope, no erosion) with minor soils in the Rozetta-Keomah-Sylvan association. Soils in the Rozetta-Keomah-Sylvan association account for 35% of soils within Peoria County and are representative of nearly level to very steep, well-drained to poorly drained upland soils (Walker 1992). The remaining 2 sites were located on Jules Silt Loam (Wheeler farm) and Warsaw Silt Loam (Root plot). These soils are the major representatives of the nearly level to strongly sloping, well-drained to poorly drained soils on stream terraces and flood plains that make up approximately 9% of soils in Peoria County. They differ from the upland Rozetta Silt Loams

Table 1. Description of cultivated hayfield and prairie sites studied

Site	Cover	Primary herbaceous species	Soil type[a]	Years in present cover	Cultivation history
Wheeler farm	legume hayfield	alfalfa, orchard grass, timothy, brome	Jules Silt Loam	7	20+ years row crops
Sandall farm	legume hayfield	alfalfa, red clover, orchard grass	Rozetta Silt Loam	12 of 14[b]	20+ years row crops
Isaac farm	legume hayfield	alfalfa, orchard grass, timothy, brome	Rozetta Silt Loam	22 of 25[c]	20+ years row crops
Root prairie	tallgrass prairie/savanna	big bluestem, Indian grass, goldenrods, asters, blazing star	Warsaw Silt Loam	na	none
Jubilee prairie	restored tallgrass prairie	big bluestem, little bluestem, Indian grass, asters, prairie dock, compass plant	Rozetta Silt Loam	at least 5	20+ years grazed pasture[d]
Brucker prairie	tallgrass prairie/savanna	little bluestem, lead plant, goldenrods, blazing star, indigo, purple coneflower	Rozetta Silt Loam	na	none

[a] Based on soil survey maps (Walker 1992). Jules and Warsaw Silt Loams are located on floodplains and stream terraces; Rozetta Silt Loams are upland soils.

[b] Field was cultivated in oats and beans for 1 year each before returning to hayfield for 2 years preceding study.

[c] Field was cultivated in corn for 3 years before returning to hayfield for 2 years preceding study.

[d] Pasture was uncultivated native grasses; plot abandoned for approximately 30 years before restoration began.

in that they have calcareous underlying material and are subject to periodic flooding (Walker 1992). Primary uses and management strategies for both upland Rozetta and the floodplain soils are similar; these soils are predominantly used in cultivated crops, pastures, or hayfields, and they require management to control erosion and maintain tilth and fertility (Walker 1992).

The 3 hayfields were chosen to reflect similar crop composition and harvest schedules. Two of the sites (Wheeler and Isaac farms) were seeded to alfalfa *(Medicago sativa)* and non-native grasses: orchard grass *(Dactylis glomerata)*, timothy *(Phleum pratense)*, and brome *(Bromus inermis)*. The third site (Sandall farm) was seeded to alfalfa, with substantial amounts of red clover *(Trifolium pratense)* and orchard grass present. All 3 sites were hayed once yearly in the fall, between July and October, and all 3 sites had annual fertilizer additions. During the first week of August, the Wheeler and Isaac farm sites received commercial fertilizer applications at a rate of 39.3 kg N, 78.6 P, and 224.6 kg K ha^{-1}. The Sandall farm site received an unmeasured organic (manure) fertilizer application. Each of the 3 hayfields had been cultivated as such for a minimum of 7 years; 2 had been in near-continuous cultivation as legume hayfields for 14 and 25 years, respectively. Although the exact cultivation history of these sites prior to seeding as legume hayfields is not known, it is generally believed that these sites were all in continuous or near-continuous cultivation in row crops, probably corn, for the previous 20–30 years or more (C. Wheeler and L. Sandall, pers. comm.).

The 3 prairie sites also were chosen to reflect similar species composition. The dominant grass and forb species on these sites are typical of mesic tallgrass prairies, and include big bluestem *(Andropogon gerardii)*, little bluestem *(Schizachyrium scoparium)*, Indian grass *(Sorghastrum nutans)*, blazing star *(Liatris spicata)*, lead plant *(Amorpha canescens)*, compass plant *(Silphium laciniatum)*, purple coneflower *(Echinacea purpurea)*, indigo (*Baptisia* spp.), and various asters (*Aster* spp.) and goldenrods (*Solidago* spp.). The prairie sites had been actively maintained and/or restored through burning regimes (all 3 sites) and intensive alien removal and native seeding regimes (Brucker and Jubilee plots) for a minimum of 5 years. Two of the sites (Root and Brucker plots) are thought to be remnant communities of virgin mesic tallgrass prairie savanna that had been degraded extensively before active management began 10–20 years before the present study (A. Frye and M. Brucker, land stewards, pers. comm.). The exact history of the restored prairie site is unknown, but it had once been grazed, cultivated pastureland that had been left abandoned for approximately 30 years before restoration efforts began (H. Gardner, land steward, pers. comm.). The major species from each prairie site are listed in table 1.

<u>Soil Sampling and Analysis</u>

Three soil samples were collected randomly from each site in 1994 during the weeks of July 1–July 16 (growing season) and October 15–October 22 (post-growing season). The samples were frozen to maintain nutrient levels until further testing could be done. Each sample was tested for organic matter content, pH, cation exchange capacity (determined via summation method), and levels of free nitrate, phosphorus, potassium, calcium, and magnesium (Mower's Soil Testing Laboratory, Toulon, Ill.). Levels of soil compaction were measured during the first sampling period using a penetrometer (Lang Penetrometer, Gulf Shores, Ala.). A total of 9 soil penetrometer readings were taken at each location, 3 readings per soil-sampling site.

Two additional soil cores were collected during the first sampling period (growing season) to examine soil aggregate structure and water-holding characteristics. One core was subjected to direct dry sieving to determine the size distribution of soil aggregates (Baver, Gardner, and Gardner 1972). The sieving was standardized to 4 minutes of vigorous, manual shaking in a series of 6 sieves to obtain 7 aggregate size fractions: >3.5 mm, 1–3.5 mm, 0.75–1 mm, 0.42–0.75 mm, 0.25–0.42 mm, 0.11–0.25 mm, and <0.11 mm. The second soil core was used to determine the maximum water-holding capacity of each soil (Gates 1949), water potential at field capacity, and moisture content and water potential during a 4-hour dry-down period. To determine maximum water-holding capacity, the intact core was placed in a plastic pot that was open on one end and closed at the other, with perforations in the closed end. The pot was set upright with the open end up. Water was added to the core from the open end in a wet/pause/wet technique until the soil was moistened. Water was then added slowly to the core from the open end until it began to drip from the bottom perforations. When dripping ceased, a small sample from the center of the core was weighed, and a second small sample was removed for water-potential determination. The sample was weighed again and placed in a drying oven, set at 130° C, for one hour. The sample was weighed, a small sample was again removed for water-potential determination, and the original sample was weighed again and placed back in the drying oven for an additional hour. This process was repeated over a 4-hour period. After each of the 5 dry-down readings, the water-potential determination was obtained using a thermocouple psychrometer (NT-3, Decagon Devices, Pullman, Wash.), and the sample was allowed to dry to a constant weight and weighed a final time. The difference between the original weight (while wet, before drying) and final dry weight divided by the dry weight is equal to the percent water content based on the dry weight (Kohnke 1968). For each location, this method gave a maximum water-holding capacity, a dry-down curve, and water potential based on percent water content.

Statistical Analysis

Organic matter content, soil pH, CEC, and nutrient contents were analyzed, using a two-way analysis-of-variance to determine the main effects of site and sampling date and their interaction (Data Desk 5.01, Data Description, Inc., Ithaca, N.Y.). Site and date were designated as fixed effects, and type III sums of squares were employed. Orthogonal contrasts were constructed (e.g., within the main effect of site and the interaction between site and sampling date) to examine the effects of vegetative cover (prairie vs. hayfield) and soil type (upland vs. floodplain), and their interactions with sampling date. All main effects, interactions, and contrasts were tested over the residual mean square (error) term. Whenever a specific contrast was significant, the contribution of that contrast to the sums of squares (SS) of the overall term (site, or site*sampling date) was computed as 100*(SS contrast/SS term).

RESULTS AND DISCUSSION

Mesic tallgrass prairie sites were significantly less compacted than cultivated legume hayfield soils (tables 2 and 3). In fact, prairie vs. hayfield cover accounted for 86% of the variation in soil compaction values across sites, while soil type (upland vs. floodplain) accounted for only 6% of the total variation (table 3). Values ranged from 291.9–737.6 kPA in prairie sites compared with 747.27–1517.3 kPA in hayfield sites. Although absolute values obtained in penetrometer studies may not be well standardized (making cross-study comparisons difficult),

Table 2. Physical, biological, and chemical properties of soils under cultivated hayfields vs. tallgrass prairies during the growing season and following the growing season

	Cultivated hayfields			Tallgrass prairies		
	Wheeler farm	Sandall farm	Isaac farm	Root prairie	Jubilee prairie	Brucker prairie
Growing season (July 5)						
Soil compaction (kPA)	951.5 ± 171.1	1297.9 ± 302.9	1021.2 ± 269.1	360.9 ± 67.6	430.6 ± 60.7	587.2 ± 222.9
Organic matter (% mass)	1.9 ± 0.1	2.0 ± 0.3	1.6 ± 0.4	4.5 ± 0.9	1.4 ± 0.1	2.0 ± 0.8
Soil pH	7.5 ± 0.1	5.7 ± 0.7	6.2 ± 0.1	7.2 ± 0.0	5.3 ± 0.6	5.3 ± 0.4
CEC (cmol(p)/kg)	12.0 ± 1.1	14.9 ± 8.1	11.8 ± 1.8	13.7 ± 1.9	18.2 ± 5.8	22.7 ± 5.5
NO3- (cmol(e)/kg)	0.046 ± 0.009	0.039 ± 0.002	0.038 ± 0.002	0.046 ± 0.013	0.034 ± 0.002	0.033 ± 0.006
PO4- (cmol(e)/kg)	0.044 ± 0.011	0.028 ± 0.022	0.007 ± 0.004	0.054 ± 0.009	0.003 ± 0.001	0.008 ± 0.004
Mg++ (cmol(p)/kg)	3.43 ± 0.31	1.42 ± 0.36	1.15 ± 0.10	3.35 ± 0.47	1.24 ± 0.12	2.19 ± 1.12
Ca++ (cmol(p)/kg)	8.26 ± 1.32	3.68 ± 0.64	6.51 ± 0.11	9.76 ± 1.27	2.78 ± 1.06	5.72 ± 1.58
K+ (cmol(p)/kg)	0.315 ± 0.043	0.167 ± 0.035	0.160 ± 0.034	0.561 ± 0.381	0.154 ± 0.037	0.352 ± 0.040
Post-growing season (October 15)						
Organic matter (% mass)	2.0 ± 0.2	2.2 ± 0.2	2.0 ± 0.3	2.8 ± 0.3	2.6 ± 0.2	2.6 ± 0.5
Soil pH	7.6 ± 0.1	5.5 ± 0.4	6.3 ±0.1	7.3 ± 0.2	5.8 ± 0.4	5.5 ± 0.5
CEC (cmol(p)/kg)	13.5 ± 0.9	17.0 ± 4.2	11.0 ± 0.2	11.7 ± 3.1	13.8 ± 4.1	20.1 ± 8.1
NO3- (cmol(e)/kg)	0.155 ± 0.001	0.154 ± 0.006	0.154 ± 0.001	0.157 ± 0.003	0.158 ± 0.002	0.156 ± 0.001
PO4- (cmol(e)/kg)	0.094 ± 0.070	0.017 ± 0.004	0.006 ± 0.002	0.058 ± 0.036	0.004 ± 0.002	0.014 ± 0.012
Mg++ (cmol(p)/kg)	3.47 ± 0.23	1.08 ± 0.08	1.31 ± 0.18	2.89 ± 0.69	0.78 ± 0.19	1.93 ± 1.45
Ca++ (cmol(p)/kg)	9.53 ± 0.74	4.21 ± 0.14	6.74 ± 0.55	8.42 ± 2.30	4.09 ± 0.88	5.43 ± 1.04
K+ (cmol(p)/kg)	0.445 ± 0.188	0.171 ± 0.033	0.162 ± 0.037	0.364 ± 0.131	0.129 ± 0.033	0.329 ± 0.081

Note: Values are averages of 3 samples ± 95% confidence intervals.

Table 3. Results of analysis-of-variance for physical, biological, and chemical properties of soils under cultivated hayfields vs. tallgrass prairies

	Soil compaction (kPa)	Organic matter (%)	Soil pH	CEC (cmol(p) /kg)	NO3- (cmol(e) /kg)	PO4- (cmol(e) /kg)	Mg++ (cmol(p) /kg)	Ca++ (cmol(p) /kg)	K+ (cmol(p) /kg)
SITE	***	***	***	***	NS	***	***	***	***
Cover	*** (86)	*** (31)	** (6)	* (25)	NS	NS	NS	NS	(*) (10)
Soil type	(*) (6)	*** (32)	*** (90)	* (25)	** (92)	*** (92)	*** (87)	*** (77)	*** (69)
SAMPLING DATE		NS	NS	NS	***	NS	NS	NS	NS
SITE*SAMPLING DATE		***	NS	NS	NS	NS	NS	NS	NS
Cover*date		NS	NS	NS	(*) (32)	NS	NS	NS	NS
Soil type*date		***(57)	NS	NS	* (62)	(*) (92)	NS	NS	NS

Note: Values are probabilities associated with F-tests of main effects of site, sampling date, and their interaction, and contrasts within site and site*sampling date for cover (hayfield vs. tallgrass prairie) and soil type (upland vs. floodplain). Probability values associated with F-tests are as follows: (*) $0.10 > p > 0.05$; * $0.05 > p > 0.01$; ** $0.01 > p > 0.001$; *** $p < 0.001$; blank = not estimable. Contributions (percent) of significant contrast terms sums of squares to overall terms sums of squares are provided in parentheses.

compaction values for hayfield sites in the present study were in the same range as those reported elsewhere for cultivated fields on silt loam soils in west central Illinois counties (Friend 1994). Previous research has indicated that cultivation practices (i.e., tillage) can contribute to soil compaction through increased erosion (Lowery et al. 1995). Tillage practice and erosion history might account in part for the more highly compacted soils in the hayfield sites, though previous studies have found that tillage only modestly increased soil compaction rates for cultivated fields on silt loam soils in west central Illinois counties (Friend 1994), or actually reduced soil compaction in clays and clay loam soil (Hubbard et al. 1994). The higher organic matter content found in the prairie sites (see below) may have also contributed to reduced soil density and compaction rates in those sites (Brady and Weil 1996).

In addition to being less compacted, soils from prairie sites had significantly higher levels of organic matter, lower pHs, and higher cation exchange capacities than soils from cultivated hayfield sites, accounting for 31%, 6%, and 25%, respectively, of the observed variation in these soil parameters across sites (tables 2 and 3). Crop removal (harvesting hay) from the hayfield sites between July and October did limit the amount of organic matter eventually incorporated into the cultivated soils (Beauchamp and Voroney 1994), and even conservative tillage practice on the hayfield sites would have further reduced soil organic matter (Eghball et al. 1994; Reicosky et al. 1995). The increased organic matter content in the prairie sites is consistent with results reported for cultivated grassland vs. native prairie sites in central Missouri (Buyanovsky, Kucera, and Wagner 1987) and is consistent with generally high levels of organic matter reported for native grassland soils (Elliott 1986). Prairie sites with higher levels of organic matter had slightly lower soil pHs, consistent with higher organic acid content on humic soils (Brady and Weil 1996). Organic matter content, soil pH, and cation exchange capacity also differed significantly between upland and floodplain soils, accounting for an additional 32%, 90%, and 25%, respectively, of the observed variation in these soil parameters across sites (tables 2 and 3). Specifically, floodplain soils had lower levels of organic matter, lower cation exchange capacities, and higher soil pHs than upland soil sites (table 2). Soil pH values for the floodplain soils were all in the "healthy" range of pH 6.0 (Romig et al. 1995); for the upland Rozetta Silt Loam soils, pH values were lower (5.3–6.3), but were either higher or within the range of values reported for moderately or severely eroded Rozetta soils for the North Central United States (Cihacek and Swan 1994). Finally, there were higher nutrient content levels in floodplain soils than in the upland soils (tables 2 and 3).

Overall, nutrient content levels were similar in the prairie and the hayfield sites, despite chemical fertilizer applications to 2 of the 3 hayfield sites and organic fertilizer (unmeasured manure) additions to the third (tables 2 and 3). In July, all sites had a similar nitrate content level of approximately 24 $mgkg^{-1}$; by October, the nitrate content of all the sites was raised by approximately 70 $mgkg^{-1}$, possibly due to in situ mineralization. Only one crop was harvested from the hayfield sites after the application of the fertilizer, removing an estimated 28.1 kg N $ha^{-1}yr^{-1}$. Therefore, approximately 11.2 more kg N were added to those sites (through a commercial fertilizer application of 39.3 kg N ha^{-1}; see Materials and Methods) than was removed. This should have given the hayfield sites an advantage over the prairie sites, but the nitrate levels were roughly similar. There was a trend toward lower nitrogen levels in prairie vs. hayfield sites at the early sampling date and higher nitrogen levels in prairie vs. hayfield sites at the later sampling date, but the differences were modest (ANOVA cover*sampling date contrast $0.10 > p > 0.05$), as shown in tables 2 and 3. The prairie sites likely experienced significant nitrogen additions through the activities of nitrogen-fixing leguminous prairie forbs (Lichtenberg et al. 1994; Wolkomir 1995).

Soil aggregate structure did not vary widely among these sites (table 4). All soils had a large proportion of macroaggregates (>0.25 mm), ranging from a minimum of 93% to a high of 99% of total aggregates in the macroaggregate size classes. Very large macroaggregates (>1 mm) were also well represented in all soils. Other studies have shown that prairie remnant soils and cultivated hayfield soils have similar aggregate structure (Elliott 1986), but native prairie soils were found to have a greater proportion of water-stable soil macroaggregates (Elliott 1986; Jastrow 1987).

Two of the 3 prairie sites had higher maximum water-holding capacities and less negative water potentials at field capacity, and dried less rapidly than their cultivated hayfield soil counterparts (table 5). The higher levels of organic matter likely contributed to the greater water-holding capacities of the prairie-cover soils (Hudson 1994).

Table 4. Distribution of soil aggregates of soils under cultivated hayfields vs. tallgrass prairies

	Cultivated hayfields			Tallgrass prairies		
Size class	Wheeler	Sandall	Isaac	Root	Jubilee	Brucker
>3.5 mm	35.0	13.2	39.0	22.6	30.7	26.4
1–3.5 mm	39.4	29.8	33.5	27.5	36.4	49.3
0.75–1 mm	13.8	20.6	13.2	17.0	18.1	15.0
0.42–0.75 mm	6.2	30.3	5.7	11.2	7.4	4.4
0.25–0.42 mm	2.5	4.9	3.1	14.7	2.8	2.2
0.11–0.25 mm	1.8	0.4	2.3	5.4	2.8	1.8
< 0.11 mm	2.4	0.8	3.2	1.6	2.5	0.9

Note: values represent percent of soil aggregates of each class size.

SUMMARY

Farmers in the twenty-first century will be increasingly faced with the challenge of retaining fertile and productive topsoil, and doing so with minimal expenditure on costly soil emendation programs (Tweeten 1995; Hoag and Skold 1996). The key to long-term sustainable agriculture is maintaining soil quality, particularly soil structure and function (Warkentin 1995). This study suggests that the health of degraded agricultural soils throughout central Illinois may be only partially restored through long-term hayfield cultivation (7–25 years). Hayfield cultivation can restore some aspects of soil health, including aggregate structure and nutrient content. Soil compaction rates remain appreciably higher, and organic matter content levels, cation exchange capacities, and water-holding capacities remain appreciably lower in agricultural soils that have been rested as hayfields relative to values in intact prairie soils. Further, prairie soils have nutrient content levels comparable to those found in the cultivated hayfields, despite a lack of applied fertilizers. Thus, state-wide programs that promote soil conservation and restoration by encouraging hayfield plantings may not adequately lead to key improvements in soil health.

The prairies created the rich soils of the Midwest that are so productive today. Prairie plants have evolved and

Table 5. Soil water-holding characteristics (% soil moisture and soil water potential in J/kg) during a 4-hour dry-down period

	Cultivated hayfields						Tallgrass prairies					
	Wheeler farm		Sandall farm		Isaac farm		Root prairie		Jubilee prairie		Brucker prairie	
Hours dried	% soil moisture	Water potential	% soil moisture	Water potential	% soil moisture	Water potential	% soil moisture	Water potential	% soil moisture	Water potential	% soil moisture	Water potential
0	41.24	−0.018	36.53	−0.013	46.04	−0.020	56.63	−0.011	49.68	−0.015	42.96	−0.022
1	38.96	−0.081	33.52	−0.085	44.30	−0.068	53.57	−0.057	46.82	−0.057	39.17	−0.079
2	33.41	−0.112	27.23	−0.127	39.29	−0.083	45.81	−0.123	38.96	−0.129	31.19	−0.129
3	29.61	−0.136	22.20	−0.134	35.46	−0.120	41.01	−0.092	34.37	−0.092	26.59	−0.114
4	25.47	−0.123	17.32	−0.109	31.72	−0.083	34.81	−0.103	28.99	−0.099	19.87	−0.116

Note: Soils were at field capacity at the onset of the dry-down period (at zero hours) and were dried in a 55°C oven.

adapted to these soils and have been instrumental in creating their chemical, physical, and biological properties. Encouraging prairie species may provide an alternative to cultivating more traditional forage crops; such species could preserve and even increase the quality and quantity of topsoil with low economic burden to smaller-scale farmers.

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BUFFALOGRASS (*BUCHLOË DACTYLOIDES* (NUTT.) ENGELM.) IN ILLINOIS

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ABSTRACT: Buffalograss (*Buchloë dactyloides* (Nutt.) Engelm.) is a warm-season grass species, possibly native in Illinois. Because of its superior adaptation to low-maintenance settings and the degree of variation that exists within the species, identifying the most appropriate types for landscape applications is of interest. A study conducted in Urbana, Illinois, at the University of Illinois Landscape Horticulture Research Center evaluated 22 buffalograss cultivars 21 times over four growing seasons. The objectives of this study were to identify differences among turfgrass quality and determine which buffalograss cultivars perform best in Illinois, in order to make cultivar recommendations. Of the 22 cultivars in the study, the commercially available '315' buffalograss performed in the upper half of all cultivars at each evaluation. 'NTDG 3,' 'NTDG 4,' and 'NTDG 5' buffalograsses also performed in the upper half of all cultivars at each evaluation, but they are not commercially available. The commercially available '609' and 'Sharps Improved' buffalograsses performed in the upper half in 20 and 19 of the 21 evaluations, respectively. Performance varied based on weather conditions during the growing seasons: hot, dry conditions favored buffalograss performance, while cool, moist conditions favored invading cool-season broad-leaved weeds and grasses. The cultivar '315' can be recommended, with reservation, for use in Illinois as a low-maintenance turf for full sun. Chemical weed controls, applied in cool, wet growing seasons, may be necessary to enhance the quality of the stand.

INTRODUCTION

Interest in low-maintenance turfgrasses suitable for Illinois has increased over the past few years. Moreover, as a result of the severe growing conditions during the 1988, 1991, and 1995 growing seasons, turfgrasses tolerant of hot and dry conditions are also of interest. Many warm-season grasses exhibit great tolerance for hot and dry conditions and limited management inputs. Not all warm-season grasses, however, tolerate the winter conditions of Illinois. Buffalograss (*Buchloë dactyloides* (Nutt.) Engelm.) is a warm-season species receiving attention from turfgrass researchers and managers because it is tolerant of temperature and moisture extremes, is adapted to many sites, requires limited maintenance, and has few pest problems. This article will describe *Buchloë dactyloides* and also review research that evaluated the performance of 22 buffalograss cultivars grown in the Illinois study during the 1992 through 1995 growing seasons.

Native Range and Occurrence in Illinois

Edna Mosher (1918), in *The Grasses of Illinois*, does not list *Buchloë dactyloides* among Illinois native grasses. Hitchcock (1951) concurred, stating that the native range of buffalograss is generally from northwestern Iowa in the east, western Louisiana and Arizona in the south, and north to Minnesota and Montana; he does not include Illinois.

More recent writings, however, do include buffalograss in the Illinois flora. Jones (1971) wrote that *Buchloë dactyloides* was discovered in Peoria in 1956 by V. H. Chase, and states that it is "apparently a relic on soil never in cultivation." Two years later, Mohlenbrock (1973) wrote that buffalograss was "known only from a cemetery in Peoria County, . . . and from a gravel bluff prairie in Winnebago County." Here Mohlenbrock also states that "Chase, who collected the first Illinois specimen, believes it is native since it grows in an undisturbed prairie remnant in a cemetery." Five years later, Mohlenbrock and Ladd (1978) added Crawford, Kane, and Kendall counties to Peoria and Winnebago counties as settings in which buffalograss has been collected. Mohlenbrock (1986) states that in Illinois, buffalograss occurs in prairies, is rare, and is confined to the northern two-thirds of the state.

Young (1994), in *Kane County Wild Plants and Natural Areas*, writes that buffalograss is a western grass that "finds a home on the edges of highways and railroads." Finally, Swink and Wilhelm (1994) indicate it was introduced from farther west and show its occurrence in Cook, DuPage, Grundy, Kane, and Will counties. They go on to state that "while it may not be a native species locally [the Chicago area], it certainly is 'more native' than *Poa pratensis!*"

Three possible explanations may clarify its rare occurrence in Illinois. It may occur as a relic of natural populations, it could be adventive (having moved in out of its natural range), or it could have been planted many years before being collected for herbaria. It remains to be determined which explanation is most accurate.

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The Plant

Buchloë dactyloides grows to a height of 10 to 15 cm and spreads by stolons, forming a dense, matted sod. Stolons grow rapidly under moist conditions and can reach 70 cm (Weaver and Albertson 1956). Its curly leaves are finely textured, usually less than 3 mm wide, slightly hairy and gray-green during the growing season (Beede 1950; Beard 1973; Turgeon 1985). When dormant, the leaves turn light tan-brown. Other vegetative features include a hairy ligule (long at the margins, short in the center), a broad, hairy collar, no auricles, rolled vernation, and short, flattened sheaths (Beede 1950; Hitchcock 1951; Beard 1973; Turgeon 1985).

Buffalograss is usually dioecious, having separate male and female plants. However, both monoecious and hermaphroditic plants have been reported (Plank 1892; Hitchcock 1895; Schaffner 1920; Anderson and Aldous 1937; Gernert 1937; Hensel 1938; Wenger 1940; Harlan 1946). The orange-tinged male flowers are visible in April through October, standing above the leaves (Beede 1950; Pohl 1978). The female flowers are borne near the leaf sheaths, often very close to the ground. Sixty to 70 days following spring green-up, seeds can be produced (Weaver and Hansen 1941). Seeds occur in burs, each bur containing from 1 to 5 caryopses, with an average of 2 to 3 (Pladeck 1940; Weaver and Albertson 1956). There are approximately 36,000 burs per pound (Wenger 1943; USDA 1948; Ahring 1964), and a bushel of fresh burs weighs approximately 15 pounds (Wheeler and Hill 1957). Upon ripening, burs and plants disarticulate (Ahring 1964). When cleaned, bur purity can reach 95%, with germination greater than 50%. The average seed purity in one test, however, was 65% (Wheeler and Hill 1957), and occasionally, the germination percentage can drop below 10% for some untreated seeds (Wheeler and Hill 1957). The seeds are long lived under proper storage conditions (Lowe 1940; USDA 1948).

Fig. 1. *Buchloë dactyloides*. Pistillate and staminate plants, × ½; pistillate spike and floret, ×5: staminate spikelet, ×5. (reprinted from Hitchcock, 1951)

Landscape Uses

Current interest in buffalograss is due to its performance as a low-maintenance turf species.

Buffalograss tolerates a wide range of environmental conditions, beginning growth in May and going dormant after the first freeze (Nuland, Reece, and Kinbacher 1981). It survives the extreme heat and cold common in its native range, and it grows in very dry loam or clay-loam soil (Beard 1973; Turgeon 1985). It does not do well, however, in shade or in sandy or highly alkaline soils. Reports indicate that under very dry conditions, one summer watering is usually adequate to keep it from going dormant. The root system of buffalograss is rather shallow, and the grass normally occurs in areas receiving 25 to 50 cm of precipitation per year (Beard 1973).

Buffalograss is considered to be a low-maintenance turfgrass species, and it can be maintained at mowing heights of 1 to 5.1 cm in lawns that require frequent cuttings (Turgeon 1985; Fermanian et al. 1997). In areas of low management, the grass survives without mowing, with one mowing per season, or with monthly mowing at 5.1 cm. Fertilizer requirements are minimal, usually 0.8–3.2 kg N/ha/month of growing season (Beard 1973; Nuland, Reece, and Kinbacher 1981; Turgeon 1985; Fermanian et al. 1997). It requires minimal irrigation because of an extremely low water-use rate (Chamrad and Box 1965; Beard 1973; Nuland, Reece, and Kinbacher 1981; Turgeon 1985). Conversely, during unusually wet periods, buffalograss tolerates long-term submersion (Porterfield 1945). Thatch management is usually unnecessary because little thatch is produced (Beard 1973).

Buffalograss has been reported to be damaged by several diseases, including *Bipolaris buchloes, Cercospora serninalis,* and *Puccinia kansensis* (Wenger 1943; Ahring 1964; Fermanian et al. 1997). Several insects have been reported to attack buffalograss. They include the buffalograss webworm *(Parapediasia teterrella)* and the May or June beetle, *(Phyllophaga crinita)*, as well as grasshoppers, leafhoppers, and the prairie ant (Ahring 1964). Southern chinch bugs (Busey and Snyder 1993) and mealy bugs (Heng-Moss et al. 1997) can also attack this grass. Weeds can be controlled in buffalograss through safe applications of several preemergence and postemergence herbicides (Meenen and Timmons 1949; Ahring 1964; Huffman and Jacoby 1984; Fry and Upham 1994; Dotray and McKenney 1996; Fry et al. 1997). At present, none of these diseases or insect pests has been reported to affect buffalograss growing in Illinois. Weed invasions into buffalograss, on the other hand, can reduce buffalograss quality (Haley and Voigt 1993).

National Turfgrass Evaluation Program

An opportunity to evaluate different strains of buffalograss in Illinois arose in 1991, when the National Turfgrass Evaluation Program (NTEP) announced that a national buffalograss evaluation would be established. The University of Illinois was among the 28 sites chosen to house the evaluation.

NTEP was established in 1980 as a nonprofit, self-supporting program jointly sponsored by the National Turfgrass Federation, Inc. (NTF) and the United States Department of Agriculture (USDA) Agriculture Research Service (ARS), Beltsville, Maryland (Morris and Murray 1993). NTEP's main function is to standardize the evaluation of turfgrass cultivars. Prior to 1980, many turfgrass researchers carried out cultivar evaluations, but these tests were not coordinated from location to location (Morris and Murray 1993).

NTEP collects and statistically analyzes cultivar performance data from university testing sites. Each year, NTEP issues a publication that reports the year's results of each national test (Morris 1996).

The Study and Its Importance

Because *Buchloë dactyloides* requires limited mowing and irrigation, precious petroleum and water resources can be conserved when it is planted. The low maintenance requirements of buffalograss, in combination with its tolerance of heat and drought and its limited pest problems, make it a turfgrass worthy of study. There were questions as to which types of the many buffalograss cultivars available would be best suited to Illinois.

The opportunity to employ NTEP evaluation methodology on buffalograss cultivars occurred in 1991. The primary objective of this study was to determine whether buffalograss is a suitable turf species for Illinois. More specifically, the 1991 study was designed to determine

a. if there are differences among the performance of 22 buffalograss cultivars,

b. which buffalograss cultivars perform best in central Illinois,

c. which buffalograss cultivars could be recommended for planting in Illinois.

METHODS

Twenty-two buffalograss cultivars were planted on June 28, 1991, at the Landscape Horticulture Research Center in Urbana, Illinois. Each cultivar was planted into the 152 cm x 152 cm center areas of plots measuring 213 cm x 213 cm. The experiment was planted into a randomized complete block design with three replications.

The plants used in the plots were produced at the University of Nebraska. They originated as vegetatively produced clones of a single genotype or as plants selected from a seeded population. Each plot was planted with 6 to 24 plugs, depending on the total quantity of plugs available for each cultivar. Table 1 lists the cultivars planted in the study, sources of the cultivars, and their vegetative or seed origins.

Prior to planting, the area was rotary tilled and supplied with 8 kg N/ha. Following planting, the plots were watered as needed to ensure establishment and mowed at 5.1 cm as needed.

Table 1. Source and origin of 22 buffalograss cultivars included in the 1992–95 NTEP evaluation in Urbana, Illinois

Cultivar	Source	Origin
AZ143	University of Arizona	vegetative
BAM101	Bamert Seed Company	seeded
BAM202	Bamert Seed Company	seeded
Bison	Native Turf Development Group	seeded
Bufflawn	Quality Turfgrass Houston, Tex.	vegetative
Highlight 15	River City Turf Farm Sacramento, Calif.	vegetative
Highlight 25	The Grass Farm Morgan Hill, Calif.	vegetative
Highlight 4	University of California Davis, Calif.	vegetative
NE 84-315	University of Nebraska	vegetative
NE 84-436	Crenshaw/Douget Turfgrass Austin, Tex.	vegetative
NE 84-45-3	University of Nebraska	vegetative
NE 84-609	University of Nebraska	vegetative
NE 85-378	University of Nebraska	vegetative
NTDG-1	Native Turf Development Group	seeded
NTDG-2	Native Turf Development Group	seeded
NTDG-3	Native Turf Development Group	seeded
NTDG-4	Native Turf Development Group	seeded
NTDG-5	Native Turf Development Group	seeded
Prairie	Texas A & M University	vegetative
Rutgers	Rutgers University	vegetative
Sharps Improved	Sharp Brothers Seed Healy, Kans.	seeded
Texoka	original source unknown	seeded

Over the duration of the study, the plots were maintained at 5.1 cm and were not irrigated. To control weeds, a postemergence broadleaf herbicide was applied in 1992, and a preemergence herbicide was applied twice in 1993. In 1993, the study received 16 kg N/ha, and in each of 1994 and 1995, the study received 8 kg N/ha.

Overall turf quality was measured during the 1992 through 1995 growing seasons. Turf quality is a subjective rating that combines several turfgrass characteristics, including uniformity, rate of spread, and the occurrence of weeds, insects, and diseases. Uniformity involves turfgrass color, leaf width (texture), density (the number of aerial shoots per unit area), and growth habit. Each plot was rated on a 1 through 9 scale in which 1 = dead turf, 5 = minimally acceptable turf quality, and 9 = perfect turf. From 1992 through 1995, buffalograss cultivar quality was evaluated 21 times (table 2).

Table 2. Evaluation months for buffalograss quality evaluations (1992–1995)

Year	Evaluation months
1992	May, June, July, August, September, October
1993	May, June, July, August, September
1994	May, June, July, August, September
1995	May, June, July, August, September

RESULTS AND DISCUSSION

Buffalograss Cultivar Quality Performance

After four growing seasons of evaluation, performance differences among the 22 buffalograss cultivars emerged. The combined performance data was analyzed in two ways. In the first analysis method, the mean performance of each buffalograss cultivar was determined over all 21 evaluations (table 3). Thus, the mean performance is an average of the turf quality of three replications and 21 evaluations over four years.

Lost in this analysis method are any outstanding or extremely poor evaluation periods. For example, poor performance evaluations during the cooler months of May and September may be masked by outstanding evaluations in July or August. There are obvious shortcomings to using means as a method of identifying a turfgrass that has acceptable, long-term performance.

When making quality evaluations, it is important to remember that a rating of 5 indicates minimally acceptable turf quality. Based on the overall quality means (table 3), none of the grasses performed at minimal quality. The study-long performance of cultivars 'NE 84-315,' 'NTDG-3,' and 'NTDG-5' most closely approached minimal quality, but each cultivar had several evaluations of unacceptable performance.

In the second analysis method, the mean for each monthly evaluation was determined. For each cultivar, the number of times its monthly rating was greater than the monthly mean was determined. Thus, there were 21 opportunities for each buffalograss cultivar to rate above the mean for the group. Results of this analysis method appear in table 4.

This second method produces results that are more useful for making recommendations. For example, poor evaluations are readily apparent, preventing cultivars from being recommended on the basis of their exceptional performance during only part of the growing season. Using this analysis method to evaluate long-term outcomes allows identification of grasses that offer relatively consistent performance throughout the growing season. Above-average turf quality throughout the growing season is more desirable than quality that oscillates between exceptional and unacceptable.

Table 3. 1992–1995 mean buffalograss cultivar quality ratings

Cultivar	Mean performance
NE 84-315	4.7
NTDG-3	4.6
NTDG-5	4.6
NE 84-609	4.4
NTDG-4	4.4
NTDG-1	4.3
NE 85-378	4.2
NE 84-436	4.1
NTDG-2	4.1
AZ143	4.0
Prairie	4.0
Sharps Improved	4.0
BAM101	3.9
BAM202	3.9
Bison	3.4
Texoka	3.4
NE 84-45-3	3.1
Bufflawn	2.3
Rutgers	2.3
Highlight 15	2.0
Highlight 25	2.0
Highlight 4	2.0

The source of the cultivars in the trial may account for some of differences in their performance ratings in Illinois. Most of the better performers in the trial originated from breeding programs or producers in the Great Plains. Cultivars from the Native Turf Development Group (based in the Great Plains) and the University of Nebraska (table 1) were among the highest-performing types. Cultivars from programs in California and Texas generally performed more poorly. The growing environment in Illinois is probably more similar to conditions in the Great Plains than to conditions in California and Texas; grasses originally selected and tested in Great Plains programs will usually perform better than those originally tested and selected in more moderate growing conditions.

Based on this analysis, 'NE 84-315,' 'NTDG-3,' 'NTDG-4,' 'NTDG-5,' 'NE 84-436,' 'NE 84-609,' 'NE

Table 4. Number of monthly evaluations in which buffalograss cultivar performance was above mean for group (1992–95)

Buffalograss cultivar	Number of evaluations above monthly mean
NE 84-315	21
NTDG-3	21
NTDG-4	21
NTDG-5	21
NE 84-436	20
NE 84-609	20
NE 85-378	19
NTDG-1	19
NTDG-2	19
Sharps Improved	19
AZ143	17
BAM202	17
Prairie	15
BAM101	13
Bison	8
Texoka	5
NE 84-45-3	3
Rutgers	1
Bufflawn	0
Highlight 15	0
Highlight 25	0
Highlight 4	0

85-378,' 'NTDG-1,' 'NTDG-2,' and 'Sharps Improved' performed in the upper half in 19 (or more) of the 21 evaluations. While not spectacular performers, any of these buffalograss cultivars might be useful for turfgrass planting in Illinois.

Additional Observations

Buffalograss quality performance was, to a great degree, controlled by weather conditions during the evaluations. For example, during warm summer periods in 1988, 1991, 1995, and 1998, buffalograss, a warm-season species, held an ecological advantage and thrived in Illinois areas where it was growing. During these same periods, cool-season broadleaf weeds and grasses were at a disadvantage and rarely invaded areas where buffalograss was growing. During normal Urbana summers, hot, dry periods are common, and buffalograss normally thrives during these periods.

In 1992 and 1993, while this study was ongoing, however, the growing seasons were wet in Urbana, and the 1992 season was also particularly cool. Under these conditions, cool-season grasses and weeds were able to invade the warm-season buffalograss, and buffalograss turf quality was reduced. Chemical weed controls are available for controlling the invaders, but the question arises as to whether chemical controls should be a required component of a low-maintenance turfgrass management.

Beyond weed invasions, the greatest stumbling block to increased buffalograss planting is probably its appearance. All of the grasses in this study were dull gray-green when actively growing and formed a less dense canopy than most turfgrasses (this may also account for some of the weed invasions into the plantings). When dormant, usually from mid October through late April in central Illinois, the study area was a dirty tan-brown.

CONCLUSIONS

All of the cultivars survived the growing conditions at the study site, but the results of quality evaluations in 1992 through 1995 show obvious differences among the 22 buffalograsses included in the study. The cultivars that had above-average monthly quality ratings for each of the 21 evaluations were 'NE 84-315,' 'NTDG 3,' 'NTDG 4,' and 'NTDG 5.' These produced a low-quality turf, based on the evaluation criteria, and would be recommended, with reservation, for planting in Illinois. Unfortunately, only one of these cultivars, 'NE 84-315' (sold as '315' buffalograss) is commercially available in the trade. Cultivars 'NE 84-609' (available as '609' buffalograss) and 'Sharps Improved' performed above the mean in 20 and 19, respectively, of the 21 evaluations and should also be considered, with reservations, for planting in Illinois.

Additional research is needed to evaluate further the buffalograsses in this study, as well as newly available buffalograss cultivars. To produce a complete package of buffalograss selection, use, and culture guides, evaluations in varied environmental and management conditions will be necessary. These continued studies will refine and enhance our knowledge of buffalograss and its appropriate use in Illinois.

Buffalograss is not the perfect grass for most applications. Its appearance, its vulnerability to invasion by cool-season weeds and grasses, and its lack of shade tolerance will keep it from replacing popular cool-season grasses in sites requiring high-quality turf. It may, however, prove to be useful in low-management sites, especially when new cultivars have been selected and optimum management regimes are defined.

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