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Oklahoma Native Plant Record

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The purpose of ONPS is to encourage the study, protection, propagation, appreciation and use of the native plants of Oklahoma. Membership in ONPS is open to any person who supports the aims of the Society. ONPS offers individual, student, family, and life memberships.

Cover photo: *Rubus* L. sp., Blackberry by Becky Sheets, first place photo winner, special category, 2010.

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Foreword

This year, our 10th year of publication, is marked by our entry into the World Wide Web. We've been working with Digital Services at Oklahoma State University's Edmon Low Library to make the *Oklahoma Native Plant Record* available to everyone, globally. We are ready for the new age of botanists who have grown up in the digital age and expect to be able to submit articles without picking up a pencil or putting a stamp on an envelope. Some of us will be challenged to think and communicate differently, as we re-tool our offices and struggle to learn electronic text, graphics, and statistics programs. We ask for your patience as we make the transition and offer our help as you continue to submit, review, and read our articles.

We have a very useful historical article this year, "The Identification of Some of the More Common Native Oklahoma Grasses by Vegetative Characters". It is the Master's thesis of William Franklin Harris, who graduated from Oklahoma Agricultural and Mechanical College (now OSU) in 1949. He submitted this as his Master's thesis the following year. Though a commonly used key to the grasses of Oklahoma, it is overdue for publication. Hopefully this version, updated by Dr. Ronald J. Tyrl, recently retired botanist from OSU, will inspire new taxonomists.

Dr. Bruce Hoagland and Ms. Amy Buthod, from the Oklahoma Biological Survey, have given us a new checklist for one of the most popular regions of the state, Ouachita National Forest. Since Thomas Nuttall's visit in 1819 the area has been inventoried numerous times, but only three floristic lists have been published for this vast and diverse area. This list of species collected at the Camp Tom Hale Scout Reservation is an extension of their 2009 study in the Cucumber Creek area, which is 66 km SE of this site. It is intended to enhance the knowledge of plant distributions in the Ouachita Mountains in LeFlore County and to be used as an educational tool by the Boy Scouts of America.

Ms. Mary Gard is a graduate of Oklahoma State University. Her preliminary research on the toxicity of *Tephrosia virginiana* plants in Oklahoma provides insight to their historic use by Native Americans to stun fish to facilitate their capture. While some of the findings of previous studies were similar, this new study also raises questions that she intends to address in future research.

Dr. Bruce Smith, our local native fern expert, has provided us another educational and enjoyable article. This year it is on ferns found in the more arid regions of Western Oklahoma. Again, he has detailed photos which illustrate Oklahoma species of this important, but often overlooked, taxon.

Because the purpose of the Society is to encourage the study of native plants, the *Record* has an obligation to its readers to be a resource for study. To that end, our "Critic's Choice" essay this year is written by Dr. Ron Tyrl. His stories are proverbially erudite, holding our attention and giving us an intriguing piece of his knowledge that keeps us wanting more. Acknowledging the importance of taxonomic identification tools, like Patricia Folley's field guide for Oklahoma wildflowers (forthcoming from Iowa Press), he underscores the importance of keys for learning those species that aren't often photographed. He provides us with an historic perspective on the format styles and use of keys like those of Harris and Linnaeus.

Sheila Strawn
Managing Editor

Oklahoma Native Plant Record
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THE IDENTIFICATION OF SOME OF THE MORE COMMON NATIVE OKLAHOMA GRASSES BY VEGETATIVE CHARACTERS

Submitted to the Department of Botany and Plant Pathology of Oklahoma Agricultural and Mechanical College [now Oklahoma State University] in partial fulfillment of the requirements for the Degree of Master of Science
1950

William Franklin Harris

INTRODUCTION

The increasing interest in grassland management in Oklahoma reveals the need for some means of identifying grasses by their vegetative characters. Native grasses comprise a major component of the state's grazing resources; hence, this work concerns itself only with those species. Several keys of local scope have been prepared for various localities, but thus far none has been made specifically for Oklahoma. It is hoped that this work will prove helpful in identifying grasses when only the vegetative part is present.

Most of the economically important native grasses of Oklahoma were collected during the season of 1949. Mature plants were collected so that each specimen could be positively identified before descriptions of the vegetative characteristics of each species were prepared. The most valuable characteristics from which to identify grasses vegetatively are found near the junction of the sheath and blade. Drawings illustrating this region have been made for each species. These, with the artificial key and brief descriptions, should enable one to determine any of the species included without too much difficulty.

REVIEW OF LITERATURE

The first published attempt at a system of identifying grasses by their vegetative characters was that by Jessen, in Germany, in 1863. Other works, some of which are listed below, have appeared at intervals up to the present, but none have applied specifically to Oklahoma.

Carrier, in 1917, published a key to forty-eight important species of eastern United States.

Norton, in 1930, prepared keys to Maryland grasses in both vegetative and flowering stages. In 1932, Keim, Beadle, and Frolik published a key to the important prairie hay grasses of Nebraska. A well-prepared key to vegetative characteristics of some Kansas grasses by Copple and Aldous appeared the same year.

Burr and Turner, in 1933, presented separate keys based on gross morphological and microscopic leaf characteristics of some British grasses.

Hitchcock's key to the grasses of Montana, published in 1936, is excellent for its illustrations and completeness; over 200 species were included. The same year, Nowosad and co-workers published an excellent series of drawings, descriptions, and a key to the pasture grasses of eastern Canada. Pechanec, in 1936, studied the grasses of the upper Snake River Plains of Idaho and published descriptions and a key to eighteen grasses of this area.

Harrington and Durrell, in 1944, included most of the important Colorado grasses in a key and descriptions based on vegetative characters.

Blomquist, in 1948, appended a short key to immature grasses in his manual of the grasses of North Carolina.

Harris, W. F.
https://doi.org/10.22488/okstate.17.100074

[Ed. Notes: Nomenclature has been updated by Ronald J. Tyrl, Emeritus Professor of Botany at Oklahoma State University, according to the National Plant Data Center, Baton Rouge, LA (http://plants.usda.gov) and the *Flora of North America North of Mexico. Magnoliophyta: Commelinidae* (in part): *Poaceae, part 1 & part 2*. Volumes 24 & 25. Oxford University Press, New York.

The original thesis used the bracketed style of listing a key. It appears here in the indented style, which is now the standard practice.

Species names have been updated. Descriptions were originally in list form, but are presented here in paragraph form.**]**

KEY FOR IDENTIFICATION

1. Vernation conduplicate.
    2. Plants annual.
        3. Ligule 0.1-0.2 mm long, membranous basally with ciliate margin; plants dichotomously branched; blades tapering to needle-like point. ..... *Aristida oligantha*
        3. Ligule a fringe of hairs 0.5-0.8 mm long; plants prostrate to decumbent, often mat-forming; blades flaccid. ..... *Cenchrus spinifex*
    2. Plants perennial.
        4. Ligule with hairy margin at least half its length. (Distinguish a hairy margin from a lacerate or toothed one.)
            5. Plants stoloniferous and creeping. ..... *Buchloe dactyloides*
            5. Plants not bearing long stolons.
                6. Blades mostly more than 5 mm wide. ..... *Tridens flavus*
                6. Blades less than 5 mm wide.
                    7. Plants with scaly, creeping rhizomes, sheaths crowded, overlapping, usually found in alkaline soil. ..... *Distichlis spicata*
                    7. Short rhizomes sometimes present, sheaths shorter than internodes.
                        8. Plants erect, unbranched; blades long, attenuate; ligule membranous basally, with ciliate margin. ..... *Sporobolus compositus*
                        8. Plants erect to decumbent; blades short (less than 15 cm long), soft, flexuous; ligule a fringe of hairs.
                            9. Blade margins conspicuously papillose-hispid; ligule a fringe of hairs less than 0.5 mm long. ..... *Bouteloua hirsuta*
                            9. Blade margins sometimes sparsely papillose-hispid; ligule often membranous basally, with ciliate margin, less than 0.3 mm long. ..... *Bouteloua gracilis*
        4. Ligules membranous more than the basal half.

10. Plants decumbent, branching from base, seldom erect; blades obtuse, less than 12 cm long; rhizomes absent.
    11. Ligule less than 1 mm long; blades conduplicate. ..... *Chloris verticillata*
    11. Ligule 1.5-3.0 mm long; blades flat, becoming conduplicate toward apex. ..... *Schedonnardus paniculatus*
10. Plants erect; blades longer; rhizomes often present.
    12. Plants glabrous throughout, except sparsely scattered long hairs at base of blade; blades very rigid, convolute; definite rhizomes present. ..... *Coelorachis cylindrica*
    12. Plants hairy, especially the blades; rhizomes usually absent.
        13. Sheaths, especially the lower, inflated and imbricated, compressed, sharply keeled, yellowish in color; ligule less than 0.5 mm long. ..... *Andropogon virginicus*
        13. Plants with sheaths not as above; ligule at least 1.0 mm long.
            14. Ligule membranous with lacerate margins; midrib very broad and prominent on both surfaces of blade; rhizomes absent. ..... *Andropogon ternarius*
            14. Ligule membranous with ciliate margins; rhizomes sometimes present. ..... *Schizachyrium scoparium*

1. Vernation convolute.
    15. Plants annual.
        16. Ligule membranous basally, less than 0.6 mm long.
            17. Plants with disagreeable odor; blade margins glandular; ligule with ciliate margins. ..... *Eragrostis cilianensis*
            17. Plants often hoary; blades short (3-8 cm long); ligule membranous, slightly toothed on margin. ..... *Hordeum pusillum*
        16. Ligule at least 0.8 mm long.
            18. Plants densely hispid throughout; nodes hispid; blades 8-20 mm wide. ..... *Panicum capillare*
            18. Plants not as above.
                19. Ligule made up entirely of hairs, or composed of hairs for more than the terminal half.
                    20. Blades less than 3 mm wide; veins and midrib inconspicuous. ..... *Sporobolus vaginiflorus*
                    20. Blades 4-6 mm wide; midrib prominent. ..... *Eriochloa contracta*
                19. Ligule membranous, at least the basal half.
                    21. Sheaths longer than internodes; blades sometimes sparsely pilose on upper surface; collar prominent, wedge-shaped. ..... *Panicum dichotomiflorum*

21. Sheaths shorter than internodes; blades papillose-pilose on upper surface toward base; collar very narrow. ..... *Leptochloa panicea*

15. Plants perennial.
22. Ligule a fringe of hairs.
23. Ligule less than 0.5 mm long.
24. Rhizomes short, stout, scaly. ..... *Eragrostis curtipedicellata*
24. Rhizomes absent.
25. Blades 15-90 cm long, attenuate; midrib broad and white; nodes crowded toward base of culm, pubescent. ..... *Eragrostis trichodes*
25. Blades much shorter; midribs not prominent; nodes glabrous.
26. Sheaths pubescent on margins. ..... *Sporobolus cryptandrus*
26. Sheaths glabrous on margins.
27. Blades sparsely pilose on upper surface; sheaths shorter than internodes, with conspicuous midveins. ..... *Eragrostis lugens*
27. Blades usually glabrous; sheaths longer or shorter than internodes. ..... *Eragrostis secundiflora*
23. Ligule at least 1 mm long.
28. Rhizomes present.
29. Ligules less than 2 mm long; plants tall and reed-like.
30. Blade margins very scabrous; midrib broad. ..... *Spartina pectinata*
30. Blade margins glabrous; midrib inconspicuous. ..... *Calamovilfa gigantea*
29. Ligules usually more than 2 mm long.
31. Blades 10-60 cm long, often glaucous or purplish; midrib broad and white. ..... *Panicum virgatum*
31. Blades 15-35 cm long; midrib inconspicuous; sheaths papillose-hirsute toward summit. ..... *Eragrostis spectabilis*
28. Rhizomes absent.
32. Ligule 3 mm long; blades less than 2 mm wide. ..... *Eragrostis sessilispica*
32. Ligule less than 2 mm long; blades more than 2 mm wide.
33. Ligule a dense fringe of hairs; collar thickened, 1.5 mm wide. ..... *Tridens albescens*
33. Ligule a fringe of loose hairs; collar very narrow and indistinct. ..... *Tridens strictus*

22. Ligule membranous, at least the basal half.
34. Auricles rounded to clawlike, sometimes clasping; ligules thick, often greenish.
35. Blades often pubescent on upper surface, 2-6 mm wide; wiry, creeping rhizomes present. ..... *Pascopyrum smithii*
35. Blades glaucous or glabrous, usually more than 6 mm wide; rhizomes very short, if present.
36. Blades often 20 mm wide, slightly scabrous on upper surface and margins; ligule usually at least 1 mm long. ..... *Elymus canadensis*
36. Blades seldom over 12 mm wide, very scabrous on margins and upper surface; ligule less than 1 mm long. ..... *Elymus virginicus*
34. Auricles rudimentary or absent; ligules usually thin and hyaline. ..... couplet 37

37. Ligules with paired lateral spurs, with vein in each spur. ..... *Sorghastrum nutans*
37. Ligules not veined nor with lateral spurs.
38. Tall, reed-like plants, often growing in shallow water; sheaths thick and pithy; ligules often 15 mm long. ..... *Zizaniopsis miliacea*
38. Plants not as above.
39. Ligules not exceeding 0.5 mm in length
40. Blades usually less than 5 mm wide; margins papillose. ..... *Bouteloua curtipendula*
40. Plants robust; blades usually at least 10 mm wide; margins glabrous, often scabrous.
41. Blades dark green, narrowed toward base, soft, flaccid, and lanceolate; rhizomes short and stout. ..... *Chasmanthium latifolium*
41. Blades rigid, usually scabrous on margin and both surfaces, tapering to long point; midrib broad and white; rhizomes thick, knotty, and often woody. ..... *Tripsacum dactyloides*
39. Ligules usually at least 1 mm long.
42. Blades less than 10 cm long.
43. Ligule bearing long, pointed teeth; rhizomes tough and scaly. ..... *Hilaria jamesii*
43. Ligule often oblique, margins entire; rhizomes absent. ..... *Digitaria cognata*
42. Blades more than 10 cm long. ..... couplet 44

44. Plants stoloniferous. ..... *Panicum obtusum*
44. Plants without long, creeping stolons.
45. Plants of moist habitats, decumbent to semi-erect; nodes and collars often purplish; blades spreading, often drooping.

46. Rhizomes short, stout, and scaly;
sheaths papillose at summit. ..... *Paspalum floridanum*
46. Rhizomes absent; sheaths glabrous to pilose,
but not papillose.
47. Plants rooting from lower nodes;
sheaths no longer than internodes. ..... *Paspalum pubiflorum* var. *glabrum*
47. Plants purplish green in color;
sheaths longer than internodes;
short, white hairs immediately
behind the ligule. ..... *Paspalum setaceum* var. *stramineum*

45. Plants of drier habitats, erect (*Bothriochloa laguroides* subsp. *torreyana* is sometimes decumbent basally), blades ascending to erect.
48. Plants erect or ascending from decumbent base;
blades and sheaths glabrous throughout;
rhizomes absent. ..... *Bothriochloa laguroides* subsp. *torreyana*
48. Plants erect, often purplish or glaucous;
blades often pubescent to pilose;
rhizomes usually present.
49. Plants with long, stout rhizomes;
blades flat to U-shaped in cross-section;
ligule 3-5 mm long. ..... *Andropogon hallii*
49. Plants sometimes having short rhizomes;
blades flat to V-shaped in section;
ligule 1-2 mm long. ..... *Andropogon gerardii*

DESCRIPTIONS OF SPECIES

Andropogon gerardii Vitman
(=A. furcatus Muhl.)
Big Bluestem

Perennial 1-2 m tall, robust, tufted, erect, sparingly branched above, often glaucous to purplish. **Culms** solid, terete, striate; nodes glabrous. **Vernation** convolute. **Blades** 10-45 cm long, 5-10 mm wide, basal leaves pointed, flat to V-shaped in section, firm; upper surface scabrous, papillose at base; veins distinct, raised above surface; midrib broad and prominent; margins scabrous. **Ligule** membranous, 1-2 mm long, truncate, ciliate to lacerate on margin. **Collar** divided by midrib, hirsute on margins. **Auricles** absent. **Sheaths** shorter than internodes, glaucous, glabrous, the lower sometimes villous toward base, striate, rounded in section, split, with a hyaline margin continuous with the ligule. **Rhizomes** short and thick, usually present.

Distribution: This species occurs abundantly on prairies, especially in more fertile soil, throughout the state.

Andropogon hallii Hack.
Sand Bluestem

Perennial 100-200 cm tall, erect, robust, glaucous, simple at the base, branched above, often tufted. **Culms** glabrous, solid, glaucous, round in section; nodes glabrous. **Vernation** convolute. **Blades** 5-45 cm long, 5-12 mm wide, glaucous, somewhat rigid, erect, flat to U-shaped in cross-section, glabrous to scaberulous on upper surface; lower surface keeled, glaucous; margins scabrous; veins raised above the surface; midrib broad and white. **Ligule** membranous, continuous with hyaline margins of the sheaths, often reddish, lacerate-toothed on margin, rounded, 3-5 mm long. **Collar** conspicuous and glabrous. **Auricles** absent. **Sheaths** glaucous, shorter than internodes, glabrous, rigid, split, round in cross-section, striate. **Rhizomes** long, stout and creeping.

Distribution: Occurs in sandy soils from the central to the western part of the state.

Andropogon ternarius Michx.
Splitbeard Bluestem, Split Bluestem

Perennial 80-100 cm tall, tufted, erect, simple below, branched above, the branches long, slender, and erect. **Culms** smooth and glabrous toward base; the upper nodes sometimes pubescent. **Vernation** conduplicate. **Blades** 10-60 cm long, 2-3 mm wide, those below the racemes very short, the basal blades often purplish-glaucous, glabrous except sometimes sparsely papillose at base, the basal blades long, attenuate, conduplicate, becoming revolute toward the apex, sometimes slightly scabrous above, flat in section, becoming revolute; margin minutely scabrous, sometimes sparsely hirsute at base; veins distinct; midrib very wide and prominent above and below. **Ligule** membranous, opaque, truncate, lacerate on margins, sometimes apparently divided by midrib, 1-2 mm long. **Collar** obscure. **Auricles** absent. **Sheaths** mostly shorter than internodes, usually somewhat scabrous, sometimes sparsely hirsute or papillose, flattened in cross-section, keeled toward the apex, split to near base. **Rhizomes** absent.

Distribution: This species appears on dry, sandy soil throughout most of the state; it seldom forms pure stands.

Andropogon virginicus L.
Broomsedge

Perennial 50-100 cm tall, tufted, erect, much branched above. **Culms** usually flattened, solid, sometimes glaucous; nodes sometimes villous. **Vernation** conduplicate. **Blades** 15-35 cm long, 2-5 mm wide, flat, becoming conduplicate toward the long, tapering apex, hirsute toward base on upper surface; margins slightly scabrous, hirsute toward base of blade; veins indistinct; midrib prominent on lower surface. **Ligule** 0.5 mm long, membranous, rounded and ciliate. **Auricles** absent. **Collar** obscure. **Sheaths** shorter than internodes, loose; lower inflated and imbricated, compressed, keeled, greenish-yellow, glabrous, except often pilose to papillose on margins, split. **Rhizomes** absent.

Distribution: This species is often abundant on open, thin soils of the eastern half of the state.

Aristida oligantha Michx.
Oldfield Threeawn, Prairie Threeawn

Annual 20-60 cm tall, erect, slender, dichotomously branched. **Culms** erect, slender, tufted, branching from the nodes, scabrous; nodes glabrous. **Vernation** conduplicate. **Blades** 10-20 cm long, 1-2 mm wide, rigid, margin sparsely ciliate, flat to convolute at apex, tapering to a needle-like point, scabrous on upper surface, often pilose near base; veins indistinct, more prominent adjacent to midrib; margin sparsely ciliate; midrib not prominent. **Ligule** membranous, ciliate on margins, approximating a fringe of hairs, 0.1-0.2 mm long. **Collar** yellowish-green, glabrous, indistinct. **Auricle** absent. **Sheaths** longer or shorter than the internodes, slightly scabrous, with membranous margins, rounded in cross-section, split to near base with margins twisted and overlapping, sometimes ciliate at the throat. **Rhizomes** absent.

Distribution: Occurs throughout the state, found in old fields, sometimes forming pure stands on thin, clay soils.

Bothriochloa laguroides (DC.) Herter subsp. ***torreyana*** (Steud.) Allred & Gould
(=Andropogon saccharoides Sw.)
Silver Beardgrass, Silver Bluestem

Perennial 40-120 cm tall, tufted, slender, simple to branched, erect or ascending from decumbent base, often genuculate at the base. **Culms** glabrous; nodes glabrous to appressed-pubescent. **Vernation** convolute. **Blades** 8-20 cm long, 3-9 mm wide, glabrous throughout, tapered on both ends, sometimes slightly scabrous on upper surface and margins; veins inconspicuous; midrib broad, keeled below. **Ligule** membranous, hyaline, the margin finely notched, 1.5-3.0 mm long. **Collar** inconspicuous, glabrous to sparsely pilose on margin. **Auricles** absent. **Sheaths** shorter than the internodes, rounded in cross-section, but keeled toward the summit, glabrous, split; margins hyaline. **Rhizomes** absent.

Distribution: This species is abundant on upland soils throughout the state.

Bouteloua curtipendula (Michx.) Torr.
Sideoats Grama

Perennial 30-100 cm tall, slender, erect, and tufted. **Culms** glabrous; internodes much shorter toward base; nodes glabrous. **Blades** 5-25 cm long, 4-5 mm wide in middle, flat, drooping, tapering to narrow point, scabrous on upper surface, pubescent on upper and lower surfaces; margin scabrous with glandular hairs, especially toward base; veins indistinct; midrib evident on upper surface. **Ligule** collarlike, membranous, 0.5 mm long, ciliate on the margin. **Collar** usually divided, yellowish-green, long-ciliate on margin. **Auricles** absent. **Sheaths** usually shorter than internodes, loose, papery on the margin, striate, round in cross-section, glabrous to sparingly pilose, throat often pilose, split to near base. **Rhizomes** short and scaly.

Distribution: This species is found in pure stands on dry hills and plains of the western part of the state.

Bouteloua gracilis (Kunth) Lag. ex Griffiths
Blue Grama

Perennial 15-50 cm tall, tufted, erect, usually branching at the base, often sod-forming. **Culms** glabrous, seldom branching from upper nodes; nodes glabrous. **Vernation** conduplicate clasping. **Blades** 5-12 cm long, 1-2 mm wide, soft; margin slightly scabrous, sparsely papillose-hirsute basally; blade flat, slightly scabrous on upper surface, narrow, drooping, tapering to long point; veins indistinct; midrib indistinct. **Ligule** 0.2-0.3 mm long, collar-shaped, mostly a fringe of hairs. **Collar** yellowish-green, divided by midrib, margin ciliate. **Auricles** absent. **Sheaths** oval to round, paler than blade, glabrous, long-ciliate at the throat, split to near base, shorter than the internodes, striate; margin membranous. **Rhizomes** absent.

Distribution: This species is one of the dominant grasses of the plains and occurs throughout the state.

Bouteloua hirsuta Lag.
Hairy Grama

Perennial 15-50 cm tall, rigid, erect to decumbent, tufted, usually sod-forming, simple, variable in habit. **Culms** striate, glabrous to pubescent below; nodes glabrous. **Vernation** conduplicate clasping. **Blades** 2-13 cm long, 1-2 mm wide, longer basally, numerous, flexuous, narrow-pointed, puberulent above, soft; midrib not prominent; margins sparsely papillose-hispid. **Ligule** a fringe of hairs 0.5 mm long. **Collar** papillose on margin, usually divided by midrib. **Auricles** absent. **Sheaths** usually shorter than internodes, loose and crowded, the upper glabrous, the lower sometimes pubescent, oval to round in cross-section, split, striate; margin hyaline. **Rhizomes** absent.

Distribution: Occurs on rocky hills and plains throughout the state.

Buchloe dactyloides (Nutt.) Engelm.
Buffalograss

Perennial sod-forming, creeping, and stoloniferous, the female plants shorter than the male, which are 10-30 cm tall, erect, and slender; the stolons from 10-30 cm long, with internodes 4-7 cm long, the nodes often rooting and bearing tufts of short leaves. **Culms** glabrous; nodes glabrous. **Vernation** conduplicate clasping. **Blades** 4-10 cm long, 1-3 mm wide, flexuous, soft, grayish-green, flat, somewhat scabrous and sparsely pubescent on upper surface; margin scaberulous, glandular; veins and midrib indistinct. **Ligule** a fringe of hairs less than 1.0 mm long. **Collar** indistinct, pilose at base and on margins. **Auricles** absent. **Sheaths** loose, round in cross-section, striate, and glabrous. **Rhizomes** absent.

Distribution: Occurs on open plains throughout the state, except the southeast part.

Calamovilfa gigantea (Nutt.) Scribn. & Merr.
Giant Sandreed

Perennial 150-300 cm tall, robust, usually solitary, rigid, unbranched. **Culms** glabrous, often glaucous; nodes glabrous. **Vernation** convolute. **Blades** as much as 70 cm long, 5-8 mm wide, rigid, flat, becoming involute toward a long attenuate apex, glabrous throughout; veins inconspicuous; lower surface somewhat keeled basally. **Ligule** a fringe of hairs 1-2 mm long. **Collar** often reddish, glabrous, sometimes ciliate on the margins. **Auricles** absent. **Sheaths** often glaucous, usually reddish, longer than the internodes, rigid, striate, often short-ciliate at the throat, split, round in cross-section, glabrous; margins overlapping. **Rhizomes** long, woody, and creeping.

Distribution: This species is a sandbinder, occurring along sandy stream banks and on sand dunes in the western part of the state.

Cenchrus spinifex Cav.
(=C. pauciflorus Benth.)
Coastal Sandbur, Common Sandbur

Annual 15-80 cm tall, prostrate to decumbent, much branched, tufted, often forming mats, somewhat stout. **Culms** flattened, sometimes scabrous, often pubescent toward summit; nodes sometimes pubescent. **Vernation** conduplicate. **Blades** 6-15 cm long, 2-9 mm wide, somewhat flaccid, flat to conduplicate, often narrowed at the base, spreading, tapering to apex, scabrous on upper surface and margins, sometimes sparingly pilose near base on upper surface; veins raised above surface; midrib prominent, keeled toward base. **Ligule** a fringe of hairs 0.5-0.8 mm long. **Collar** usually divided by midrib, wedge-shaped, sparsely ciliate on the margins. **Auricles** absent. **Sheaths** shorter than the internodes, often loose and inflated, split, flattened in cross-section and keeled toward summit, thin, striate, glabrous except occasionally pilose at the throat, often scabrous on back of midrib; margins hyaline, occasionally ciliate. **Rhizomes** absent.

Distribution: This species occurs in waste places, usually on sandy soils, throughout the state.

Chasmanthium latifolium (Michx.) H.O. Yates
(=Uniola latifolia Michx.)
Broadleaf Chasmanthium, Indian Woodoats

Perennial 60-120 cm tall, dark green, unbranched, erect, with broad, flat blades. **Culms** glabrous; nodes glabrous, often purplish. **Venation** convolute. **Blades** 10-20 cm long, 1-2 cm wide, dark green, soft, flaccid, narrowed toward the base, flat, lanceolate, short-pointed, glabrous except occasionally sparsely pubescent on upper surface at base; margins scaberulous; veins 5 on each side of semi-prominent midrib. **Ligule** membranous with short-ciliate margin, truncate, mostly less than 0.5 mm long. **Collar** glabrous, wedge-shaped, often purplish. **Auricles** absent. **Sheaths** shorter than internodes, dark green in color, round in cross-section, split, striate, much narrower than blade, glabrous throughout. **Rhizomes** short and stout.

Distribution: This species occurs in colonies in moist, wooded habitats throughout most of the state.

Chloris verticillata Nutt.
Tumble Windmill-Grass

Perennial 10-40 cm tall, tufted, decumbent to erect, often rooting at lower nodes, branching from the base; leaves crowded to the base. **Culms** flattened; the branches flattened, glabrous; nodes glabrous. **Vernation** conduplicate. **Blades** 2-12 cm long, 1-3 mm wide, obtuse, soft, often pubescent on lower surface, scaberulous on upper surface, conduplicate, drooping; margin hyaline and minutely scabrous; veins distinct; midrib prominent on lower surface. **Ligule** membranous, fringed on margin, almost divided into halves, less than 1 mm long. **Collar** divided by the midrib, indistinct, glabrous. **Auricles** absent. **Sheaths** shorter than the internodes, loose, compressed, glabrous; midvein prominent; margins hyaline. **Rhizomes** absent.

Distribution: Occurs on open prairies throughout the state.

Coelorachis cylindrica (Michx.) Nash
(=Rottboellia cylindrica Torr.)
Carolina Jointgrass, Jointtail Grass

Perennial 30-90 cm tall, erect, tufted, slender, branching toward the summit. **Culms** round, glabrous; nodes glabrous. **Vernation** conduplicate. **Blades** 15-40 cm long, 2-3 mm wide, longer basally, flat, becoming involute, stiff, tapering to a long point, scabrous on upper surface, scaberulous on lower surface, occasional long hairs on upper surface basally; margin slightly scabrous; veins distinct; midrib prominent. **Ligule** membranous, truncate, lacerate on margins, 0.5 mm long. **Collar** indistinct, narrow, divided by the midrib. **Auricles** absent. **Sheaths** longer than internodes, striate, rounded in cross-section, glabrous to scaberulous, rather loose and split. **Rhizomes** short.

Distribution: This species occurs in sandy soil in the eastern half of the state.

Digitaria cognata (Schult.) Pilg.
(=Leptoloma cognatum (Schult.) Chase)
Fall Witchgrass

Perennial 20-70 cm tall, slender, branched below, tufted, erect, becoming geniculate. **Culms** glabrous or pubescent toward base; nodes glabrous. **Vernation** convolute. **Blades** mostly less than 10 cm long, 2-5 mm wide, flat, rigid, tapering to narrow point; upper surface scaberulous, sometimes sparsely pubescent; the lower surface sparsely pubescent; veins indistinct; midrib semi-prominent, more evident below; margins wavy, hyaline, scaberulous. **Ligule** often oblique, membranous, hyaline, truncate, 1 mm long. **Collar** often paralleling an oblique blade base, glabrous, usually divided by midrib. **Auricles** absent. **Sheaths** shorter than internodes, the upper glabrous, the lower somewhat pubescent, loose, round in cross-section and split. **Rhizomes** absent.

Distribution: Occurs on dry soils throughout the state.

Distichlis spicata (L.) Greene
(=D. stricta (Torr.) Rydb.)
Saltgrass

Perennial 10-60 cm tall, rigid; leaves conspicuously distichous; plant freely branching, often glaucous. **Culms** glabrous; nodes glabrous. **Vernation** conduplicate clasping. **Blades** 5-10 cm long, 2-4 mm wide, flat or U-shaped toward the acuminate tip, crowded, rigid, ascending, glabrous to pubescent on both surfaces; margin scabrous; veins raised; midrib inconspicuous. **Ligule** collar-shaped, mostly a fringe of hairs less than 0.5 mm long. **Collar** wedge-shaped, conspicuous, pubescent on margins. **Auricles** absent. **Sheaths** crowded, overlapping, glabrous, except pubescent at throat, rounded in cross-section, split, striate, almost white in color. **Rhizomes** scaly, creeping.

Distribution: Occurs on saline and alkaline soils throughout the state.

Elymus canadensis L.
Canada Wildrye, Great Plains Wildrye

Perennial 60-150 cm tall, dark green or glaucous, simple, erect, tufted, or forming a loose sod. **Culms** glabrous, often glaucous; nodes glabrous. **Vernation** convolute. **Blades** 10-30 cm long, 4-20 mm wide, dark green, often glaucous, erect, rigid, flat, sharp-pointed, narrowed toward base, slightly scabrous on upper surface and margins, glabrous on lower surface; veins raised above surface, numerous; midrib keeled toward base on lower surface. **Ligule** membranous, thick, finely toothed to ciliate, truncate, 0.5-1.5 mm long. **Collar** distinct, oblique, wedge-shaped, sometimes divided by midrib, glabrous. **Auricles** rounded to clawlike, narrow, sometimes clasping. **Sheaths** longer than internodes, glabrous, split, round in cross-section, green or glaucous, striate; margins overlapping and hyaline, the outer margin sometimes ciliate. **Rhizomes** short, if present.

Distribution: Occurs in moist habitats throughout the state.

Elymus virginicus L.
Virginia Wildrye

Perennial 60-90 cm tall, smooth, tufted, erect, simple, rigid, and robust. **Culms** glabrous; nodes glabrous. **Vernation** convolute. **Blades** 10-30 cm long, 4-12 mm wide, flat, constricted basally, tapering to a short point, scabrous on upper surface, often glaucous, glabrous and green on lower surface; margins scabrous; veins distinct, ridged; midrib prominent; blade keeled on lower surface toward base. **Ligule** membranous, thick, greenish, truncate, minutely ciliate on margin, 0.5-1.0 mm long. **Collar** prominent, often diagonal, glabrous, greenish-yellow. **Auricles** 0.5-1.5 mm long, sharp and clawlike to round-pointed. **Sheaths** shorter or longer than the internodes, loose, glabrous to pubescent, striate, scaberulous, split, rounded; margins overlapping, the outer margin ciliate, the inner margin glabrous and hyaline. **Rhizomes** absent.

Distribution: Occurs in colonies along stream banks and in wooded sections throughout the state.

Eragrostis cilianensis (All.) Vignola ex Janch.
Stinkgrass

Annual varying from 15-50 cm tall, with glandular depressions on the branches, densely tufted, decumbent or geniculate to erect, soft. **Culms** branched, glabrous; nodes glabrous, encircled below by a ring of glands. **Vernation** convolute. **Blades** 6-25 cm long, 2-7 mm wide, flat, lower surface smooth; upper surface scabrous; veins inconspicuous; midrib prominent, especially below; margin scabrous, glandular toward base. **Ligule** membranous basally; margin ciliate-lacerate; approximately 0.5 mm long. **Collar** indistinct, pilose at margins. **Auricles** absent. **Sheaths** shorter than internodes, loose, round in cross-section, keeled toward summit, split, striate, glabrous, sometimes pilose at throat; margin hyaline. **Rhizomes** absent.

Distribution: A weed in fields and waste places; it occurs throughout the state.

Eragrostis curtipedicellata Buckley
Gummy Lovegrass

Perennial 30-90 cm tall, erect or decumbent from a bulbous base, tufted, sparsely branched. **Culms** rigid and smooth; nodes glabrous. **Vernation** convolute. **Blades** 6-15 cm long, 1-5 mm wide, flat, usually involute toward apex, tapering to fine point, thin, narrowed and boat-shaped basally, upper surface and margins scaberulous, somewhat keeled below, often glandular-viscid below; veins raised above the surface. **Ligule** a fringe of very short hairs, 0.2 mm long. **Collar** divided by midrib, distinct, 1-2 mm wide, pilose on the margins. **Auricles** absent. **Sheaths** longer than internodes, somewhat loose, usually glandular-viscid, villous at the throat, rigid, round in cross-section, striate and split. **Rhizomes** very short, stout, and scaly.

Distribution: Occurs in colonies in open habitats throughout the state.

Eragrostis lugens Nees
Mourning Lovegrass

Perennial 20-60 cm tall, slender, tufted, geniculate at base, erect, simple or sparingly branched. **Culms** wiry and glabrous; nodes glabrous. **Vernation** convolute. **Blades** 10-25 cm long, 1-3 mm wide, flat to involute at the apex, often sparsely pilose on upper surface, glabrous on lower surface, scaberulous on margins and upper surface, narrowed toward base; veins 2-3 on each side of semi-prominent midrib. **Ligule** a dense uneven fringe of hairs less than 0.5 mm long. **Collar** thickened, indistinct, divided by midrib, sparsely pilose on margins. **Auricles** absent. **Sheaths** loose, shorter than internodes, rigid, compressed at base of plant, greenish-yellow, split, oval in cross-section, glabrous, pilose at throat; midvein prominent. **Rhizomes** absent.

Distribution: Occurs in colonies in dry soils in eastern and central Oklahoma.

Eragrostis secundiflora J. Presl
Red Lovegrass

Perennial 20-40 cm tall, tufted, erect, and simple. **Culms** glabrous; nodes glabrous. **Vernation** convolute. **Blades** 5-30 cm long, 1-4 mm wide, flat, boat-shaped at base, involute toward long,

attenuate apex; lower surface glabrous; scaberulous on upper surface and margins; veins and midrib indistinct. **Ligule** a fringe of short hairs, 0.2-0.4 mm long. **Collar** divided by midrib, wedge-shaped, distinct, pilose on margins. **Auricles** absent. **Sheaths** longer or shorter than internodes, split, rounded in cross-section, glabrous, pilose at throat. **Rhizomes** absent.

Distribution: Occurs in sandy soils throughout the state.

Eragrostis sessilispica Buckley
Tumble Lovegrass

Perennial 20-40 cm tall, tufted, ascending to erect, slender, rigid, with one node above the basal cluster of leaves, branching from the base. **Culms** glabrous; nodes glabrous. **Vernation** convolute. **Blades** 3-15 cm long, less than 2 mm wide, rigid, flat to somewhat involute, acuminate, glabrous to somewhat scabrous on upper surface, occasionally sparsely pilose basally; margins scaberulous; veins distinct, raised above the upper surface; midrib inconspicuous. **Ligule** a white, uneven fringe of hairs 3 mm long. **Collar** inconspicuous, pubescent to pilose basally and on margins. **Auricles** absent. **Sheaths** longer than the internodes, rigid, glabrous, pilose at the throat, split, round in cross-section. **Rhizomes** absent.

Distribution: Occurs on dry sandy soil throughout the state.

Eragrostis spectabilis (Pursh) Steud.
Purple Lovegrass

Perennial 30-60 cm tall, simple, tufted, erect or ascending, rigid. **Culms** rigid, glabrous; nodes glabrous. **Vernation** convolute. **Blades** 15-35 cm long, 3-8 mm wide, rigid, flat, becoming involute, tapering to fine point, smooth on lower surface, scabrous on upper surface, hirsute at base, pubescent at apex on upper surface; margin scaberulous; veins distinct; midrib indistinct, more prominent on lower surface. **Ligule** a fringe of hairs, 2-4 mm long. **Collar** divided by midrib, pilose at base. **Auricles** absent. **Sheaths** longer than internodes, constricted at throat, papillose-hirsute toward summit, throat pilose, round in cross-section, split, striate, yellowish-green; margins hyaline. **Rhizomes** short, stout, and scaly.

Distribution: Occurs in dry soils throughout the state.

Eragrostis trichodes (Nutt.) Alph. Wood
Sand Lovegrass

Perennial 60-120 cm tall, tufted, erect, simple and smooth, and slender. **Culms** glabrous; nodes crowded toward base, pubescent. **Vernation** convolute. **Blades** 15-90 cm long, 2-10 mm wide, smooth on lower surface, narrowed toward the base, flat to somewhat involute, tapering to a very slender point; upper surface often pilose near base, somewhat scabrous toward apex; margins smooth to scaberulous; veins raised above surface, midrib prominent and white. **Ligule** a fringe of hairs less than 0.5 mm long. **Collar** wedge-shaped, prominent, divided by midrib, pilose basally and on margins. **Auricles** absent. **Sheaths** crowded toward base of plant, longer than internodes, greenish-yellow, glabrous except pilose at throat, keeled toward summit, split, striate, and rigid. **Rhizomes** absent.

Distribution: Occurs in sandy soils throughout the state.

Eriochloa contracta Hitchc.
Prairie Cupgrass

Annual 30-70 cm tall, densely tufted, decumbent at base, otherwise erect, freely branching above. **Culms** pubescent above; pubescent to puberulent at the nodes. **Vernation** convolute. **Blades** 12-20 cm long, 4-6 mm wide, flat, boat-shaped near base, becoming convolute on drying, flaccid, tapering to long point, pubescent to puberulent on upper and lower surfaces; veins indistinct; midrib prominent; margins smooth. **Ligule** mostly a fringe of soft white hairs 0.8-1.0 mm long, base membranous. **Collar** divided by midrib, indistinct and pubescent. **Auricles** absent. **Sheaths** longer or shorter than internodes, thin, loose, glabrous to short-pubescent, rounded in cross-sections, striate, split; margin not hyaline. **Rhizomes** absent.

Distribution: This species is found in moist cultivated and waste places throughout the state.

Hilaria jamesii (Torr.) Benth.
Galleta

Perennial 30-100 cm tall, tufted, stiff, erect or ascending from decumbent base; roots strong. **Culms** glabrous; nodes villous. **Vernation** convolute. **Blades** 2-8 cm long, 2-4 mm wide, rolled to U-shaped in cross-section, rigid, becoming involute toward apex; upper surface scabrous; veins conspicuous above; antrorsely scabrous above, retrorsely scabrous below; midrib conspicuous above; margins scabrous. **Ligule** 2.5-3.5 mm long, membranous, truncate, bearing long, pointed teeth. **Collar** of the upper leaves pilose to papillose-pilose on margins, otherwise glabrous to pubescent. **Auricles** absent. **Sheaths** overlapping below, retrorsely scabrous from sides of veins, shorter than internodes, somewhat loose, sometimes sparingly villous at throat, oval in cross-section; margin thick, papery; veins distinct. **Rhizomes** tough, scaly, creeping, and coarse.

Distribution: Occurs in dry, thin soil in the Panhandle.

Hordeum pusillum Nutt.
Little Barley

Annual 10-35 cm tall, decumbent to erect, hoary, and tufted. **Culms** glabrous; nodes glabrous. **Vernation** convolute. **Blades** 3-8 cm long, 1-4 mm wide, flat to involute when dry, erect, often flexuous, soft, often sparsely pubescent on margins and surfaces; upper surface and margin scaberulous; margin sometimes short-ciliate; veins conspicuous above; midrib prominent on lower surface. **Ligule** membranous, slightly toothed on margin, truncate, 0.3-0.6 mm long. **Collar** wedge-shaped, yellowish-green, divided by midrib, occasionally pubescent, especially on the margins. **Auricles** absent. **Sheaths** rigid, shorter than internodes, usually pubescent, sometimes pilose at the throat, split, round in section, pinkish-green when young; margins membranous. **Rhizomes** absent.

Distribution: Occurs as a weed in overgrazed pastures and fields throughout the state.

Leptochloa panicea (Retz.) Ohwi
(=Leptochloa filiformis (Lam.) P. Beauv.)
Red Sprangletop

Annual 30-90 cm tall, erect, geniculate below, branched. **Culms** sometimes reddish to purplish, smooth and glabrous; nodes glabrous. **Vernation** convolute. **Blades** 10-20 cm long, 5-10 mm wide, thin, flat, soft, narrowed and boat-shaped toward base, scaberulous on margins and both surfaces, sparsely papillose on upper surface toward base; veins distinct; midrib prominent below. **Ligule** hyaline basally, rounded with a broad, lacerate-toothed margin, 1-2 mm long. **Collar** very narrow, indistinct, divided by midrib, pubescent basally and on margins. **Auricles** absent. **Sheaths** shorter than internodes, papillose-hirsute, the lower usually smooth and glabrous, somewhat loose, split, margins overlapping, round in cross-section; margin hyaline. **Rhizomes** absent.

Distribution: A weed in moist cultivated fields and waste places throughout most of the state.

Panicum capillare L.
Witchgrass

Annual 20-80 cm tall, hairy, erect to spreading at base, tufted, simple to sparingly branched basally. **Culms** papillose-hispid to almost glabrous; densely hispid at the nodes. **Vernation** convolute. **Blades** 10-25 cm long, 8-20 mm wide, the larger ones slightly constricted at the base, somewhat short-pointed, hispid on both surfaces; veins indistinct; midrib broad, white, prominent; margins papillose-hispid. **Ligule** a fringe of hairs 0.8-1.5 mm long, with membranous base. **Collar** narrow, indistinct and hispid. **Auricles** absent. **Sheaths** longer that internodes, densely papillose-hispid, loose, round in cross-section, split. **Rhizomes** absent.

Distribution: This species occurs in fields and waste places throughout the state.

Panicum dichotomiflorum Michx.
Fall Panicum

Annual 50-200 cm tall, tufted, robust, purplish, ascending from geniculate to prostrate base, branched. **Culms** succulent, flattened, thick, usually glabrous, rarely pubescent; nodes swollen. **Vernation** convolute. **Blades** 10-50 cm long, 3-20 mm wide, thin, boat-shaped toward base, flat to conduplicate, tapering to narrow apex, upper surface and margin scaberulous, sometimes sparsely pilose on upper surface; veins distinct; midrib broad and white. **Ligule** membranous basally, the upper half a ciliate fringe 1-2 mm long. **Collar** prominent, wedge-shaped, swollen, divided by midrib, occasionally pilose on margins, bisected by distinct veins continuous from blade to sheath. **Auricles** absent. **Sheaths** longer than internodes, compressed toward the summit, loose, glabrous, sparsely pilose at the throat, striate, split; margins hyaline. **Rhizomes** absent.

Distribution: This species occurs as a weed in moist cultivated fields and waste places throughout the state.

Panicum obtusum Kunth
Vine Mesquite

Perennial 20-80 cm tall, stoloniferous with stolons sometimes 15-18 feet long, stiff, erect to decumbent at base, tufted from a knotted crown, simple or branching at the base. **Culms** compressed, glabrous; nodes glabrous. Nodes of stolons swollen and lanate, the internodes long. **Vernation** convolute. **Blades** 5-20 cm long, 2-7 mm wide, flat to keeled or involute toward long narrow apex, firm, erect; upper surface glabrous to scabrous, with sparse hairs toward base; veins raised; midrib prominent above; margins scabrous. **Ligule** membranous, hyaline, lacerate; margin rounded; 1-1.5 mm long. **Collar** indistinct, pilose on margins. **Auricles** absent. **Sheaths** shorter than internodes, loose, the lower sometimes pubescent, otherwise glabrous, round in cross-section, split; midvein prominent on inner surfaces. **Rhizomes** short and knotty.

Distribution: Occurs along sandy or gravelly stream banks and ditches throughout the state.

Panicum virgatum L.
Switchgrass

Perennial 75-200 cm tall, robust, tufted to sod-forming, often glaucous, unbranched, erect. **Culms** glabrous, often glaucous; nodes glabrous. **Vernation** convolute. **Blades** 10-60 cm long, 3-15 mm wide, often glaucous or purplish, flat, erect, tapering to a long point, upper surface usually pilose near base, becoming pubescent to glabrous toward apex; lower surface smooth; margins scabrous; veins indistinct; midrib broad and white. **Ligule** a fringe of hairs 3-5 mm long, sometimes membranous basally. **Collar** glabrous to pubescent, indistinct. **Auricles** absent. **Sheaths** longer than internodes, pubescent on margins, round in cross-section, split, striate, firm, often purplish. **Rhizomes** numerous, stout, scaly, and creeping.

Distribution: Occurs abundantly in open habitats throughout the state.

Pascopyrum smithii (Rydb.) Barkworth & D.R. Dewey
(=Agropyron smithii Rydb.)
Western Wheatgrass

Perennial 30-60 cm tall, sod-forming, rigid, often glaucous, smooth and glabrous, mostly solitary with sterile shoots from base. **Culms** rigid, glaucous, pale toward the base; nodes glabrous. **Vernation** convolute. **Blades** 10-25 cm long, 2-6 mm wide, conspicuously ribbed, stiff, flat, often keeled toward apex, narrow pointed, scabrous or pubescent on upper surface; margin toothed; veins prominent. **Ligule** 0.5-0.8 mm long, collar-shaped, thick, pale green, margin very finely fringed. **Collar** smooth, divided by midrib. **Auricles** large, 1-2 mm long. **Sheaths** shorter than internodes, glaucous, glabrous to scaberulous, strongly striated, split, oval in cross-section; margin hyaline, slightly scabrous. **Rhizomes** wiry, creeping, relatively smooth.

Distribution: Occurs throughout the state except in the southeastern part. Often sown as a pasture crop.

Paspalum floridanum Michx.
Florida Paspalum

Perennial 1-2 m tall, robust, simple, solitary to small-tufted. **Culms** compressed, glabrous; nodes glabrous. **Vernation** convolute. **Blades** 15-35 cm long, 4-15 mm wide, the upper narrowed and boat-shaped basally, stiff, mostly spreading and ascending at the summit, flat to folded, papillose-pilose on the upper surface, occasionally so on the lower surface, scaberulous on upper surface and margins; margins hyaline; veins distinct, raised on upper surface; midrib broad, white and prominent below. **Ligule** membranous, truncate, lacerate-toothed on margin, 2-3 mm long. **Collar** divided by midrib, indistinct, narrow, pubescent, pilose on margins. **Auricles** absent. **Sheaths** longer than internodes, overlapping toward base of culm, the upper sometimes shorter than internodes, keeled, striate, glabrous to papillose-hirsute, throat papillose, split, flattened in cross-section; margin papery. **Rhizomes** short, stout, and scaly.

Distribution: Occurs throughout the state in low, moist places.

Paspalum pubiflorum Rupr. ex E. Fourn. var. ***glabrum*** Vasey ex Scribn.
Hairyseed Paspalum

Perennial 50-100 cm tall, decumbent to ascending. **Culms** geniculate to decumbent at base, glabrous; nodes dark purple; lower nodes pubescent. **Vernation** convolute. **Blades** 10-30 cm long, 6-12 mm wide at base, flat, thin, tapering to long point, somewhat scabrous on upper surface, often papillose basally, otherwise glabrous; margin sparsely ciliate and minutely scabrous; veins numerous, indistinct; midrib prominent on lower surface. **Ligule** membranous, glabrous, thin, transparent, rounded with lacerate margins, 1.0-2.0 mm long. **Collar** sometimes greenish-purple, glabrous; ciliate on margin, not divided by midrib. **Auricles** absent. **Sheaths** longer than internodes, loose, slightly paler than blade, rounded in cross-section, split to near base with margins overlapping; margin long-ciliate toward apex. **Rhizomes** absent.

Distribution: This species is found in moist soils throughout the state, except the extreme western part.

Paspalum setaceum Michx. var. ***stramineum*** (Nash) D.J. Banks
(=P. stramineum Nash)
Yellow Sand Paspalum

Perennial 40-100 cm tall, yellowish-green, small-tufted, basally branched, erect or ascending to spreading, slender, often purplish toward the base. **Culms** glabrous, compressed; nodes pubescent. **Vernation** convolute. **Blades** 6-20 cm long, 6-15 mm wide, shorter toward upper part of the plant, drooping, narrowed and boat-shaped basally, glabrous to puberulent on both surfaces, often pilose toward base; margins scaberulous, often papillose basally. **Ligule** membranous, hyaline, irregularly toothed on the margin, about 1 mm long; short, white hairs occur immediately behind the ligule. **Collar** puberulent, wedge-shaped, usually purplish. **Auricles** absent. **Sheaths** no longer than internodes, loose, ciliate on margins, often pilose at the throat, striate, split, somewhat flattened in cross-section, keeled toward summit, often purplish toward base of plant. **Rhizomes** absent.

Distribution: Occurs on moist, sandy soils throughout the state.

Schedonnardus paniculatus (Nutt.) Trel.
Tumblegrass

Perennial 20-50 cm tall, leaves crowded at base, spreading to erect, tufted, branching from base. **Culms** slender, green to purplish, hollow, rigid, smooth, and glabrous; nodes glabrous. **Vernation** conduplicate or conduplicate clasping. **Blades** 2-6 cm long, 1-3 mm wide, flexuous, flat, becoming conduplicate toward tips, blunt pointed; upper surface scabrous, glabrous on lower surface; margins scabrous; midrib prominent below. **Ligule** acute, membranous, hyaline, 1.5-3.0 mm long; margin lacerate. **Collar** indistinct. **Auricles** absent. **Sheaths** loose, compressed, crowded toward the base of the plant, glabrous, scabrous on back of midvein, split, greenish-yellow in color; margins hyaline, continuous with ligule. **Rhizomes** absent.

Distribution: Occurs in dry grassland throughout the state.

Schizachyrium scoparium (Michx.) Nash
(=Andropogon scoparius Michx.)
Little Bluestem

Perennial 40-150 cm tall, tufted, erect, slender, much branched, often glaucous, green to reddish-purple in color. **Culms** glabrous; nodes glabrous. **Vernation** conduplicate. **Blades** 5-25 cm long, 3-7 mm wide, flat to conduplicate in cross-section, tapering to a narrow point, occasionally glabrous, but usually scabrous and pubescent on upper surface, hirsute toward the base; lower surface glabrous to sparingly pubescent; margins scabrous; veins raised above surface; midrib conspicuous, especially on lower surface. **Ligule** membranous with ciliate margins, truncate, 1.0-1.5 mm long. **Collar** somewhat thickened, rarely pubescent. **Auricles** absent. **Sheaths** shorter than internodes, flattened, pubescent at the throat, glabrous to pubescent, split; margins papery, often ciliate. **Rhizomes** short, if present.

Distribution: This species is the dominant grass over large areas of Oklahoma.

Sorghastrum nutans (L.) Nash
Indiangrass

Perennial 50-250 cm tall, tufted to sod-forming, unbranched, erect, and robust. **Culms** glabrous; nodes pubescent. **Vernation** convolute. **Blades** 10-30 cm long, 5-10 mm wide, often glaucous, thickened and narrowed toward base, U-shaped toward base, becoming flat toward long tapering apex, very scabrous on both surfaces and margin, rigid, somewhat keeled on lower surface toward base; margins often hispid; veins conspicuous; midrib broad and white. **Ligule** continuous with margins of sheath, bearing on each side a one-nerved spur, rounded in center, margin notched to entire, 2-4 mm long, pinkish-brown when young. **Collar** broad, pinkish, glabrous with occasional hairs on margins. **Auricles** absent. **Sheaths** longer than internodes below, shorter above, glabrous to pubescent, broader than the blades, often brownish-purple, split, rounded, striate, rigid, often keeled toward summit; margins membranous. **Rhizomes** creeping, scaly.

Distribution: This species is found in open woods and prairies, especially in moist habitats throughout the state.

Spartina pectinata Bosc ex Link
Prairie Cordgrass

Perennial 100-200 cm tall, erect, and unbranched. **Culms** robust, glabrous; nodes lanate-pubescent. **Vernation** convolute. **Blades** 60-100 cm long, 5-15 mm wide, thick, rigid, flat, becoming involute toward apex, attenuate, tapering to a long, slender point, glabrous except occasionally scaberulous on the upper surface; margins very scabrous; veins indistinct; midrib broad, keeled on lower surface. **Ligule** a fringe of hairs 1-2 mm long. **Collar** wedge-shaped, glabrous, and thickened. **Auricles** absent. **Sheaths** glabrous, overlapping and crowded below, firmly supporting the stem, round in cross-section, split, and firm. **Rhizomes** stout, creeping, and pointed.

Distribution: Occurs in colonies in swamps and low moist areas throughout most of the state.

Sporobolus compositus (Poir.) Merr.
(=Sporobolus asper (P. Beauv.) Kunth)
Rough Dropseed, Composite Dropseed

Perennial 50-120 cm tall, erect, tufted, simple, often stout. **Culms** often purplish, glabrous; nodes glabrous. **Vernation** conduplicate clasping. **Blades** 10-60 cm long, 1-4 mm wide, the upper short, the basal long, attenuate, flat, drooping, becoming involute toward the apex; upper surface occasionally pubescent; margin scabrous; veins prominent on upper and lower surface; midrib prominent. **Ligule** very short, less than 0.5 mm long, membranous with long-ciliate margin, the hairs equaling in length the membranous base. **Collar** wedge-shaped, long-ciliate on the margins. **Auricles** absent. **Sheaths** shorter than the internodes, glabrous, pilose at the throat, often inflated, contracted toward the summit, round in cross-section, split; margin papery. **Rhizomes** short, if present.

Distribution: This species occurs throughout the state; it is found on dry prairie soils and is abundant in some localities.

Sporobolus cryptandrus (Torr.) A. Gray
Sand Dropseed

Perennial 40-100 cm tall, semi-erect, branching from the base, and tufted. **Culms** glabrous; nodes glabrous. **Vernation** convolute. **Blades** 5-15 cm long, 3-6 mm wide, longer toward base, flat, tapering to a long involute point, soft in texture; the lower surface glabrous; the upper surface scaberulous; margins somewhat scabrous, hyaline; veins 4 each side of indistinct midrib. **Ligule** a fringe of very short hairs less than 0.5 mm long. **Collar** wedge-shaped, distinct, long-pilose basally and at margins. **Auricles** absent. **Sheaths** longer than internodes above, the lower shorter, striate, split, rounded in cross-section, pubescent on margin, conspicuously pilose at throat. **Rhizomes** absent.

Distribution: This species occurs in sandy soils throughout the state.

Sporobolus vaginiflorus (Torr. ex A. Gray) Alph. Wood
Poverty Dropseed, Poverty Grass

Annual 15-50 cm tall, slender, erect or spreading from a geniculate base, tufted, and branching. **Culms** somewhat rough; nodes glabrous. **Vernation** convolute. **Blades** much longer basally, the lower 3-15 cm long, the upper often less than 1 cm long, less than 3 mm wide, involute toward the tip, ascending, the upper surface scabrous, often sparsely pilose near base and on margins; margins scabrous; veins and midrib inconspicuous. **Ligule** a fringe of hairs, 1.0-1.5 mm long. **Collar** distinct, wedge-shaped, divided by midrib, sometimes sparsely pilose on margins. **Auricles** absent. **Sheaths** shorter than the internodes, somewhat scabrous, often pilose at the throat, wider than the blades, round in section, split, loose, swollen and enclosing cleistogamous spikelets late in the season; margins hyaline. **Rhizomes** absent.

Distribution: Occurs on dry soils throughout the state.

Tridens albescens (Vasey) Wooten & Standl.
(=Triodia albescens Vasey)
White Tridens

Perennial 40-70 cm tall, erect, loosely tufted. **Culms** usually simple, glabrous; nodes glabrous. **Vernation** convolute. **Blades** 15-30 cm long, 2-7 mm wide, basal longer than upper, slender, flat, soon becoming involute, tapering to narrow point; glabrous on upper surface, except pilose at base; margin slightly scabrous; veins indistinct; midrib prominent on upper and lower surface. **Ligule** a dense fringe of hairs 1.0-1.5 mm long. **Collar** thickened below, 1.5 mm wide, pilose on margins. **Auricles** absent. **Sheaths** shorter than internodes, round in cross-section, flexible, pilose at throat, otherwise glabrous, split. **Rhizomes** absent.

Distribution: This species occurs in moist habitats in the eastern half of the state; it is common, but not abundant.

Tridens flavus (L.) Hitch.
(=Triodia flava (L.) Hitch.
Purpletop Tridens

Perennial 60-150 cm tall, semi-erect, and tufted. **Culms** simple, elliptical in cross-section toward base of plant; nodes glabrous, often purple. **Vernation** conduplicate. **Blades** 10-30 cm long, upper shorter, 3-12 mm wide, flat, boat-shaped near base, pointed toward apex, drooping; upper surface scabrous, pubescent toward base; margin scaberulous; midrib prominent below. **Ligule** a fringe of short hairs 0.5 mm long. **Collar** divided by midrib, pubescent on lower surface and on ends. **Auricles** absent. **Sheaths** shorter than internodes, overlapping at base, loose, glabrous, except occasionally pubescent on lower sheaths, pubescent at throat, oval in cross-section, split; ribs inconspicuous; margin hyaline. **Rhizomes** short, stout.

Distribution: Occurs in dry meadows throughout the state.

Tridens strictus (Nutt.) Nash
(=Triodia stricta (Nutt.) Benth.)
Longspike Tridens

Perennial 50-150 cm tall, tufted, erect, usually stout, sometimes branched. **Culms** glabrous, striate, sometimes purplish-green. **Vernation** convolute. **Blades** 10-60 cm long, 3-7 mm wide, elongate, flat to loosely involute, smooth, glabrous except pubescent on upper surface at base; margin glabrous; veins indistinct; midrib a broad band 1 mm wide, not distinct. **Ligule** a fringe of loose hairs 1-2 mm long. **Collar** indistinct, narrow, pubescent. **Auricles** absent. **Sheaths** longer or shorter than internodes, loose, somewhat striate, oval in cross-section, glabrous, sometimes pubescent at throat, split. **Rhizomes** absent.

Distribution: Occurs in moist soil in the eastern half of the state.

Tripsacum dactyloides (L.) L.
Eastern Gamagrass

Perennial 100-200 cm tall, robust, occurring in large tufts, branched, with many sterile shoots arising from the base. **Culms** flattened, glabrous; nodes glabrous. **Vernation** convolute. **Blades** 30-60 cm long, 10-30 mm wide, variable, those of the basal sterile shoots much longer than those of the flowering culms, flat, tapering to a fine point, truncate at the base, usually scabrous on the margin and on both surfaces, glabrous except sometimes sparsely hispid on the upper surface; veins raised above the surface; midrib broad and white. **Ligule** collar-like, bearing a fringe of minute hairs less than 0.4 mm long. **Collar** narrow, distinct, glabrous. **Auricles** absent. **Sheaths** shorter than internodes, those of the sterile shoots much shorter than the blades, often wider than the blades, glabrous, yellowish-green, strongly flattened, with a prominent midrib, striate, constricted at the collar. **Rhizomes** thick, knotty, and often woody.

Distribution: Occurs in wet habitats throughout the state.

Zizaniopsis miliacea (Michx.) Döll & Asch.
Water Millet, Giant Cutgrass

Perennial 1-4 m tall, robust, marsh-inhabiting. **Culms** flattened, glabrous; nodes glabrous. **Vernation** convolute. **Blades** 30-150 cm long, 1-2 cm wide, narrowed and thickened toward base, yellowish-green basally, keeled and pithy toward base, otherwise flat, glabrous throughout except the scabrous margins; midrib stout, white, and pithy, especially toward base; veins not conspicuous. **Ligule** membranous, hyaline, thin, rounded, 6-15 mm long; margin entire in younger leaves. **Collar** prominent, glabrous, relatively narrow, wedge-shaped, not divided. **Auricles** absent. **Sheaths** compressed toward summit, greenish-yellow, thick and pithy, usually longer than internodes, split; margins hyaline and continuous with ligule. **Rhizomes** stout and creeping.

Distribution: Occurs in colonies along stream banks and in swamps primarily in the southeastern part of the state.

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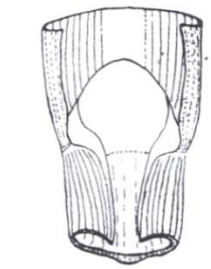
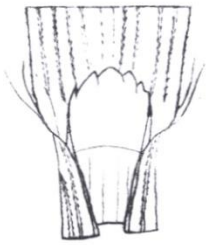
PLATES

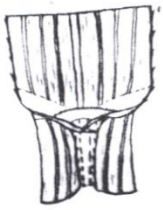
[Ed. Note: These plates are presented as they were in the original thesis.**]**



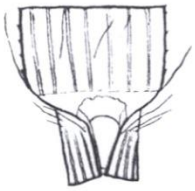
1. Zizaniopsis miliacea



2. Hilaria jamesii

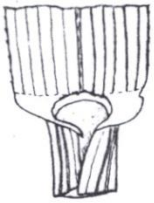


3. Agropyron smithii

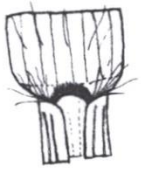


4. Hordeum pusillum

5. Elymus virginicus

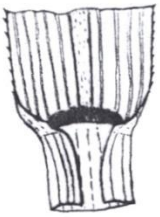


6. Elymus canadensis

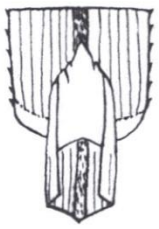


7. Buchloe dactyloides

8. Leptochloa filiformis



9. Spartina pectinata



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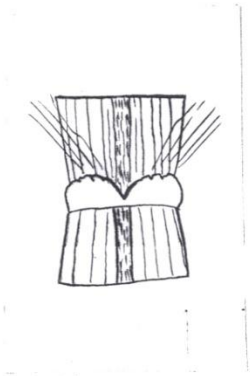
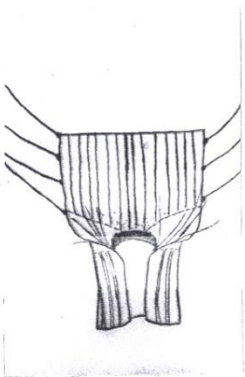
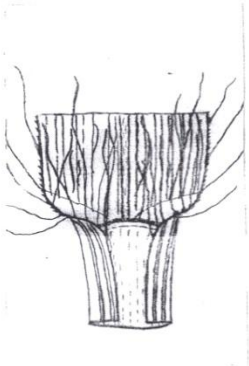


11. Chloris verticillata

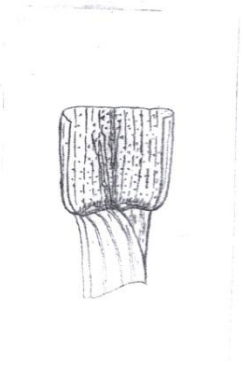
12. Boutelova gracilis



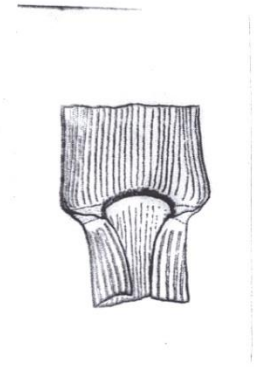
13. Boutelova hirsuta



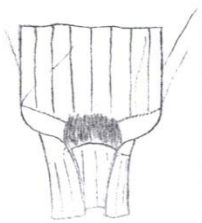
14. Boutelova curtipendula



15. Aristida oligantha



16. Calamovilfa gigantea



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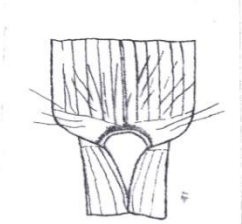
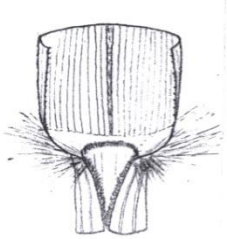
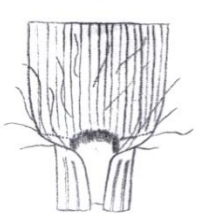


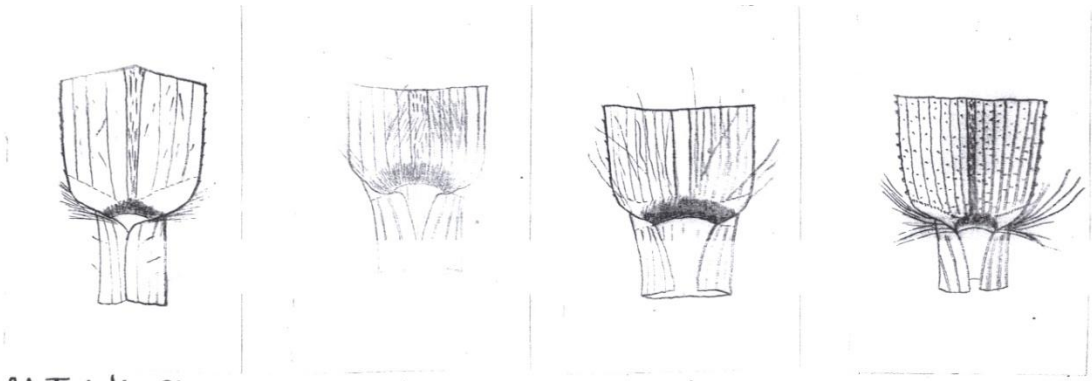
18. Sporobolus asper



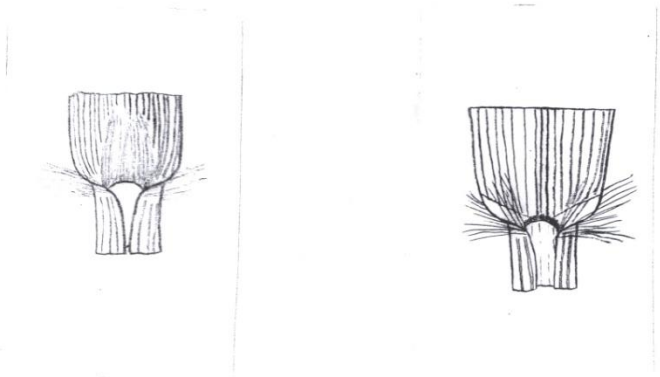
19. Sporobolus cryptandrus



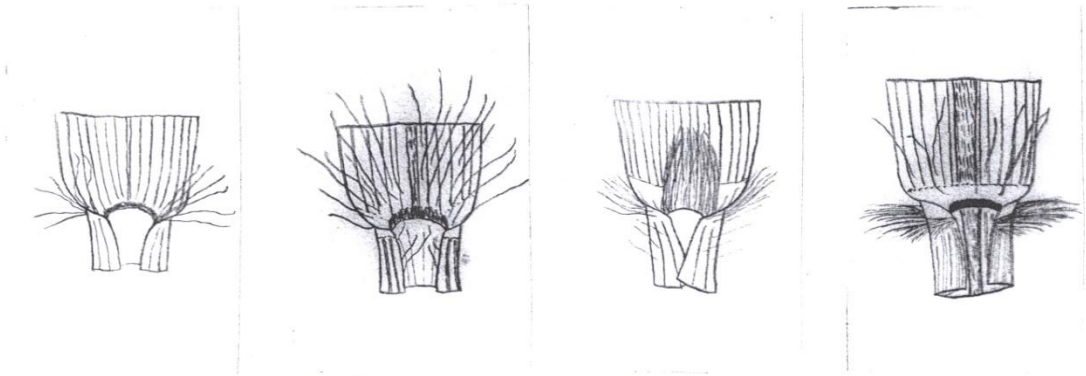
20. Distichlis stricta



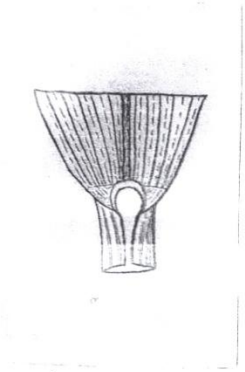
21. Triodia flava 22. Triodia stricta 23. Triodia albescens 24. Eragrostis cilianensis



25. Eragrostis sessilispica 26. Eragrostis curtipedicellata



27. Eragrostis secundiflora 28. Eragrostis lugens 29. Eragrostis spectabilis 30. Eragrostis trichodes



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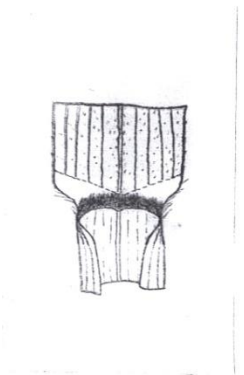
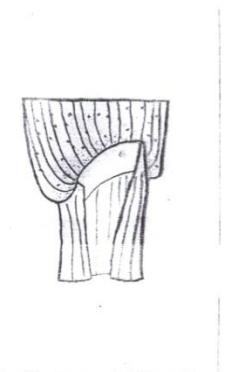
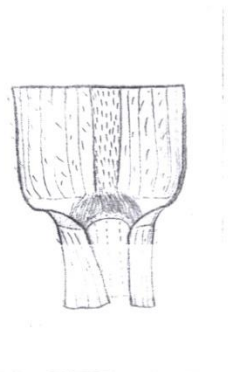


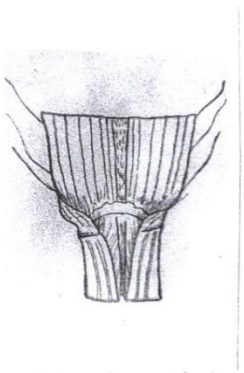
32. Cenchrus pauciflorus



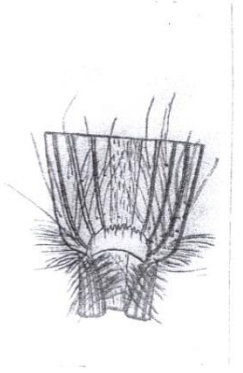
33. Leptoloma cognatum



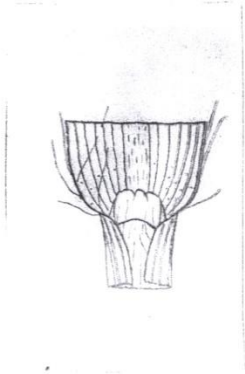
34. Eriochloa contracta



35. Paspalum stramineum

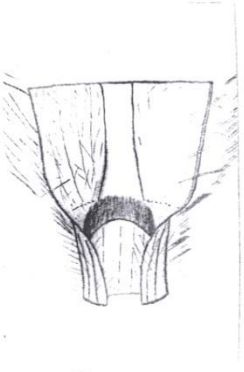


36. Paspalum Floridanum

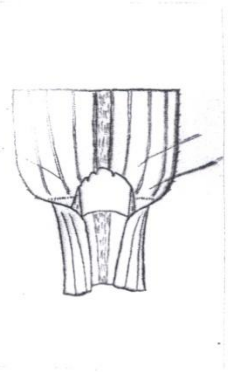


37. Paspalum pubiflorum var. glabrum

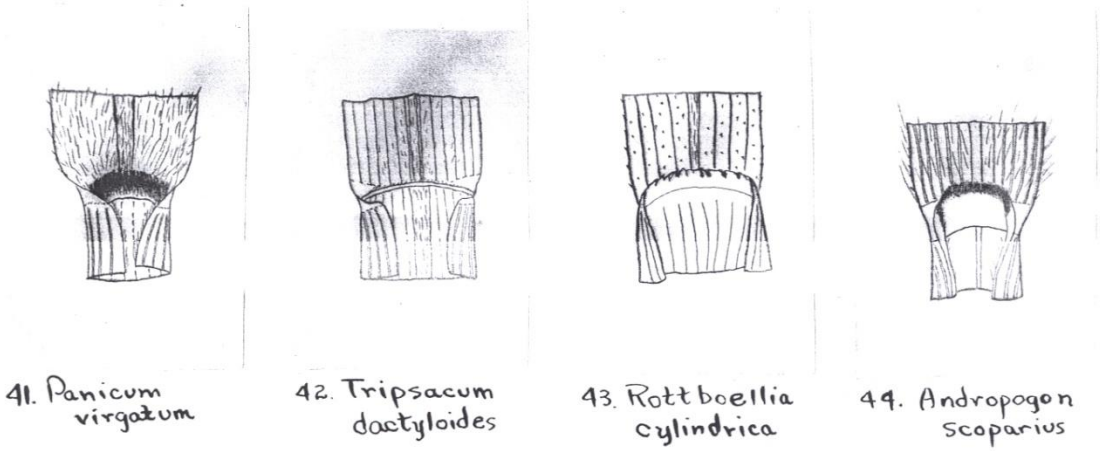
38. Panicum dichotomiflorum



39. Panicum capillare



40. Panicum obtusum

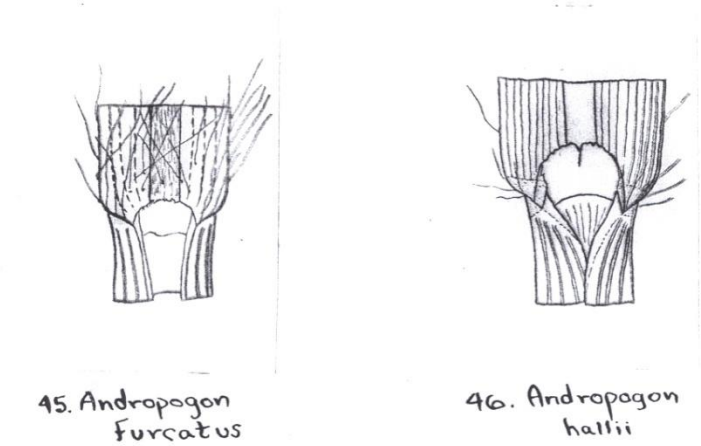


41. Panicum virgatum

42. Tripsacum dactyloides

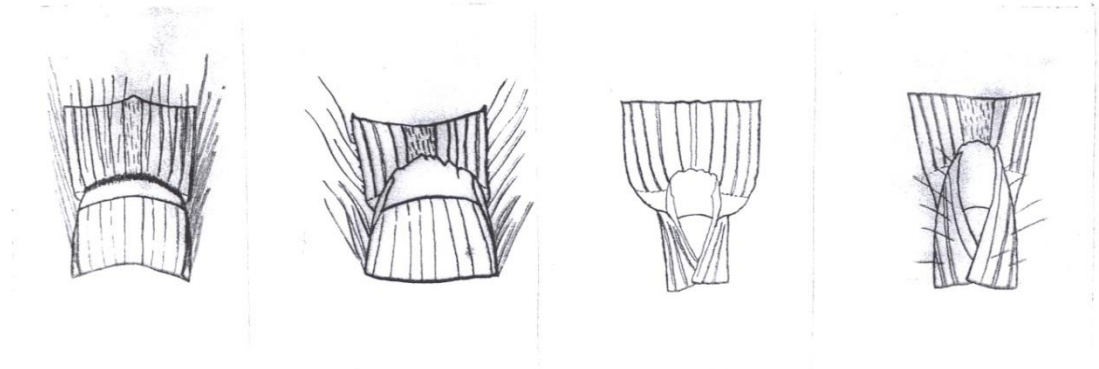
43. Rottboellia cylindrica

44. Andropogon scoparius



45. Andropogon furcatus

46. Andropogon hallii



47. Andropogon virginicus

48. Andropogon ternarius

49. Andropogon saccharoides

50. Sorghastrum nutans

APPENDIX

ALPHABETICAL LIST OF THE SPECIES DESCRIBED IN THE REPORT

Current Species Name	Plate Number
Andropogon gerardii	45
Andropogon hallii	46
Andropogon ternaries	48
Andropogon virginicus	47
Aristida oligantha	15
Bothriochloa laguroides	49
Bouteloua curtipendula	14
Bouteloua gracilis	12
Bouteloua hirsute	13
Buchloe dactyloides	7
Calamovilfa gigantean	16
Cenchrus spinifex	32
Chasmanthium latifolium	31
Chloris verticillata	11
Coelorachis cylindrical	43
Digitaria cognate	33
Distichlis spicata	20
Elymus canadensis	6
Elymus virginicus	5
Eragrostis cilianensis	24
Eragrostis curtipedicellata	26
Eragrostis lugens	28
Eragrostis secundiflora	27
Eragrostis sessilispica	25
Eragrostis spectabilis	29
Eragrostis trichodes	30
Eriochloa contracta	34
Hilaria jamesii	2
Hordeum pusillum	4
Leptochloa panicea	8
Panicum capillare	39
Panicum dichotomiflorum	38
Panicum obtusum	40
Panicum virgatum	41
Pascopyrum smithii	3
Paspalum floridanum	36
Paspalum pubiflorum var. glabrum	37
Paspalum setaceum var. *stramineum*	35
Schedonnardus paniculatus	10

Schizachyrium scoparium	44
Sorghastrum nutans	50
Spartina pectinata	9
Sporobolus compositus	18
Sporobolus cryptandrus	19
Sporobolus vaginiflorus	17
Tridens albescens	23
Tridens flavus	21
Tridens strictus	22
Tripsacum dactyloides	42
Zizaniopsis miliacea	1

THE VASCULAR FLORA OF HALE SCOUT RESERVATION LEFLORE COUNTY, OKLAHOMA

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Keywords: diversity, endemic, inventory, Ouachita Mountains

ABSTRACT

The Hale Scout Reservation is located in the Ouachita Mountains of southeastern Oklahoma, a region of high plant diversity in the state. A vascular plant inventory yielded 463 species of vascular plants in 288 genera and 99 families. The largest families were the Asteraceae (with 65 species) and Poaceae (56). The flora consisted of 120 annuals, 1 biennial, and 342 perennials. Forty-two non-native species were collected, representing 8.8% of the flora. Sixteen species tracked by the Oklahoma Natural Heritage Inventory were present: *Amorpha ouachitensis* (S1), *Aristolochia serpentaria* (S1), *Baptisia nuttalliana* (S2), *Brachyelytrum erectum* (S1), *Brasenia schreberi* (S1), *Carex ouachitana* (S1), *Chionanthus virginicus* (S2), *Clematis crispa* (S1), *Didiplis diandra* (S1S2), *Galium arkansanum* (S2), *Houstonia ouachitana* (S1), *Juncus repens* (S1), *Modiola caroliniana* (S2), *Monotropa hypopithys* (S1), *Muhlenbergia bushii* (S1), and *Ribes cynosbati* (S2) (Oklahoma Natural Heritage Inventory, 2010).

INTRODUCTION

The Ouachita Mountains are a region of high species richness and habitat diversity within the Interior Highlands of the United States (Zollner et al. 2005). The first botanist to visit the Oklahoma Ouachita Mountains was Thomas Nuttall during his expedition from Fort Smith to the Kiamichi River in 1819. Since then, the unique nature of the Ouachita Mountain flora has continued to attract botanists. In April 1913, almost a century after Nuttall, G. W. Stevens visited the Ouachitas and collected 350 plant specimens (Hoagland et al. 2010). Drawing upon botanical records from the region, Zollner et al. (2005) compiled a list of 31 vascular plant species endemic to the Ouachita Mountains. Nineteen of these occur in Oklahoma. In addition, several state rare plant species tracked by the Oklahoma Natural Heritage Inventory (ONHI; 2010) occur in the Ouachitas.

Despite a long history of botanical collecting in the Ouachita uplift, only three floristic lists from the Oklahoma Ouachitas have been published: Smith et al. (1997), Crandall and Tyrl (2006), and Hoagland and Buthod (2009). Smith et al. (1997) inventoried the vascular flora of the McCurtain County Wilderness Area located 66 km southeast of our study site in the Beavers Bend Hills sub-region of the Ouachitas. Fifty-one km west of our study area in Pushmataha County, Crandall and Tyrl (2006) inventoried the vascular plants of Oklahoma Department of Wildlife Conservation's Pushmataha Wildlife Management Area. Hoagland and Buthod (2009) inventoried The Nature Conservancy's Cucumber Creek Nature Preserve 31 km east in LeFlore County.

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The objective of this study was to inventory the vascular plants of the Hale Scout Reservation. The resulting list will be used as an educational tool at the camp and will enhance the knowledge of plant distributions in the Ouachita Mountains.

STUDY AREA

The Hale Scout Reservation (HSR) is located in the Ouachita Mountains of LeFlore County, Oklahoma (34.736° latitude, 94.888° longitude). It is a 192.4 hectare (= 475.4 acre) inholding within the Ouachita National Forest and has been operated by the Boy Scouts of America since 1961 (Boy Scouts of America 2010). Elevation at the site ranges from 251 m to 457 m. The site is drained by Bohannon Creek, which bisects HSR from north to south, and is impounded by 7.7 hectare Bohannon Lake.

The climate is subtropical humid (Cf) (Trewartha 1968). Summers are warm and humid (mean July temperature = 26.9° C; 80 ° F) and winters are relatively short and mild (mean January temperature = 2.7° C; 37 ° F). Mean annual precipitation is 122 cm; 48 in., with the highest monthly precipitation occurring in April (13 cm; 5.1 in.) and May (15 cm; 5.9 in., Oklahoma Climatological Survey 2010).

The HSR is located in the Ridge and Valley Belt of the Ouachita Mountain physiographic province of southeastern Oklahoma (Curtis and Ham 1979). The region is characterized by broadly folded Mississippian and Pennsylvanian sandstones (Branson and Johnson 1979). Soils on the floodplain of Bohannon Creek belong to Kenn-Ceda complex, which occurs on slopes of 0-2% and are occasionally flooded (Abernathy et al. 1983). The surface layer is dark brown in color and ranges from 18 – 20 cm (7.1-7.9 in.) in depth. The upland soils belong to the Carnasaw-Caston complex and the Carnasaw-Octavia complex. The Carnasaw-Caston complex consists of two units, one on slopes of 4%-15%, the other on slopes of 15%-35%. These soils are well-drained, with a surface layer of brown stony loam approximately 7.6 cm (3 in.). The Carnasaw-Octavia complex occupies slopes of 35% - 50% and is well-drained, dark grayish brown, and varies from sandy loam to stony loam.

METHODS

Plant collections were made opportunistically throughout the study area from June 2006 through October 2007. The predominant vegetation associations of HSR were classified according to Hoagland (2000). Vouchers for exotic species were made from naturalized populations only, thus excluding cultivated and ornamental plants. Specimens were processed at the Robert Bebb Herbarium (OKL) at the University of Oklahoma following standard procedures. Manuals used for specimen identification included Waterfall (1973), Smith (1994), and Yatskievych (1999). Origin, either native or introduced to North America, was determined using the United States Department of Agriculture-Natural Resources Conservation Service (2010). Nomenclature and systematics also follow the USDA-NRCS (2010). Voucher specimens were deposited at the Robert Bebb Herbarium at the University of Oklahoma.

RESULTS AND DISCUSSION

A total of 463 vascular plant species in 288 genera and 99 families were collected at HSR, including seven species of ferns (1.5% of the flora), one gymnosperm (0.22%), 333 dicots (72%), and 123 monocots (26.5%) (Table, Appendix). The Asteraceae and Poaceae had the greatest numbers of species, with 65 and 56, respectively. The largest genus was *Carex* with 14 species (3%). There were 120 annuals (25.9%), 1 biennial, and 343 perennials (73.9%).

Ninety-four species (27.6%) were trees (49 species), shrubs (31), or woody vines (14). Forty-two species (8.8%) were non-native to North America.

Sixteen species tracked by the Oklahoma Natural Heritage Inventory (2007) were encountered: *Amorpha ouachitensis* (G3QS1), *Aristolochia serpentaria* (G4S1), *Baptisia nuttalliana* (G5S2), *Brachyelytrum erectum* (G5S1), *Brasenia schreberi* (G5S1), *Carex ouachitana* (G4S1), *Chionanthus virginicus* (G5S2), *Clematis crispa* (G5S1), *Didiplis diandra* (G5S1), *Galium arkansanum* (G5S2), *Houstonia ouachitana* (G3S1), *Juncus repens* (G5S1), *Modiola caroliniana* (G5S2), *Monotropa hypopithys* (G5S1), *Muhlenbergia bushii* (G5S1), and *Ribes cynosbati* (G5S2). Species are ranked according to level of imperilment at the state (S) and global (G) levels on a scale of 1 through 5, where 1 represents a species that is critically imperiled and 5 one that is secure (Groves et al. 1995). *Galium arkansanum* and *Houstonia ouachitana* are endemic species of the Ouachita Mountains (Zollner et al. 2005).

The HSR flora consists of more species than the Cucumber Creek Nature Preserve (with 341 species), McCurtain County Wilderness Area (359), and Pushmataha Wildlife Management Area (447), which is interesting since these sites are larger than the HSR; Cucumber Creek Nature Preserve = 1,333 ha, McCurtain County Wilderness Area = 5,701 ha, and Pushmataha Wildlife Management Area = 7,690 ha. As expected, there are numerous species that occur in both the HSR flora and the other sites; HSR shares 236 shared species with the Pushmataha Wildlife Management Area and 178 with Cucumber Creek Nature Preserve. Smith et al (1997) did not include a species list, so comparison with HSR flora was not possible.

Land use and the number of non-native species might account for the greater number of species at HSR. In the case of Cucumber Creek, the site has very little development and consists primarily of second growth, closed canopy forests. Of the three sites, the Pushmataha WMA has the most development for hunting and recreation. The McCurtain County Wilderness Area could be characterized as intermediate. The HSR, however, is heavily developed to maximize potential as a Scouting venue. This is reflected in its number of non-native species (42 species), which is greater than that from the Cucumber Creek Nature Preserve (16), the McCurtain County Wilderness (21), and the Pushmataha Wildlife Management Area (31).

Four vegetation associations were identified at HSR. Dry upland forests were the most prevalent natural vegetation type, followed by the extensive area that suffers from anthropogenic disturbance. Although Bohannon Lake occupies a small percentage of the total area at HSR, it supported numerous wetland and aquatic plant species. Descriptions of all vegetation categories follow.

1. *Pinus echinata – Quercus rubra – Quercus falcata* forest association (PEQRF)

This was the predominant upland forest type, but in some locales, *P. echinata* was absent. In these situations, *Q. velutina* was the co-dominant. Canopy cover was closed for the most part, but small patches of open woodland did exist. Associated species included *Antennaria plantaginifolia, Carya texana, Clitoria mariana, Helianthus hirsutus, Hypericum hypericoides, Scutellaria ovata, Tephrosia virginiana, Vaccinium arboreum,* and *V. pallidum*. *Aristolochia serpentaria* and *Baptisia nuttalliana* are species tracked by ONHI that were found in this habitat type.

2. *Acer saccharum – Quercus alba – Carya alba* forest association (ASQA)

This forest association occurred on low and north-facing slopes. *Pinus echinata* and other xeric tree species were often canopy components, but not dominants. *Quercus rubra* and *Nyssa sylvatica* were locally

abundant. Associated species included *Agrimonia rostellata, Asclepias quadrifolia, Frangula caroliniana, Fraxinus americana, Geum canadense, Morus rubra, Nyssa sylvatica*, *Ostrya virginiana, Phlox pilosa* ssp. *ozarkana, Podophyllum peltatum*, *Polystichum acrostichoides*, and *Zizia aurea. Brachyelytrum erectum*, *Carex ouachitana*, *Chionanthus virginicus*, *Clematis crispa, Galium arkansanum*, *Houstonia ouachitana, Modiola caroliniana*, *Monotropa hypopithys*, *Muhlenbergia bushii*, and *Ribes cynosbati* are species tracked by ONHI found in this habitat.

3. Wetland (WETL)

Wetland vegetation was restricted to Bohannon Lake and consisted of emergent and floating leaf vegetation. Emergent vegetation occurred along the banks of the lake and consisted of species such as *Amorpha fruticosa, Carex crinita*, *Cornus obliqua, Eleocharis quadrangulata*, *Hydrolea ovata*, *Juncus effusus*, *Polygonum lapathifolium, Sagittaria platyphylla,* and *Steinchisma hians.* The predominant species of floating leaf vegetation were *Brasenia schreberi* and *Nuphar lutea.* Associated species included *Elodea canadensis, Nymphaea odorata*, *Myriophyllum heterophyllum, Polygonum hydropiperoides, Potamogeton nodosus*, and *Spirodela polyrrhiza.* Species tracked by ONHI in this habitat were *Brasenia schreberi*, *Didiplis diandra*, and *Juncus repens.*

4. Disturbed areas and old fields (DAOF)

Locations, including mown lawns, campsites, roadsides, or sites exhibiting signs of physical disruption, were designated as disturbed areas. Common plants in disturbed areas included *Ambrosia bidentata*, *Andropogon virginicus, Conyza canadensis, Cynodon dactylon, Digitaria sanguinalis, Lespedeza cuneata, Kummerowia stipulacea, Rhus glabra, Sorghum halepense,* and *Trifolium dubium. Modiola caroliniana* is a species tracked by ONHI found in this habitat.

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Table Summary of floristic collections from HSR in the Ouachita Mountains, LeFlore County, Oklahoma *

Taxonomic Group	Species	Native	Exotic
Pteridophyta	7	7	0
Coniferophyta	1	1	0
Magnoliophyta			
Magnoliopsida	332	304	28
Liliopsida	123	109	14
Total	463	421	42

* Table format follows Palmer et al. (1995).

APPENDIX

Annotated species list for the Hale Scout Reservation, LeFlore County, Oklahoma. Nomenclature and systematics also follows the USDA-NRCS (2010). The first entry indicates habitat (ASQA=*Acer saccharum – Quercus alba – Carya alba* forest association, DAOF = disturbed areas and old fields, PEQR = *Pinus echinata – Quercus rubra – Quercus falcata* forest association, WETL = wetland and riparian). Habitat designation is followed by life history (A=annual, B=biennial, P=perennial), and collection number. Species not native to North America are noted with an asterisk (*) and species tracked by the Oklahoma Natural Heritage Inventory with a symbol (+). Voucher specimens were deposited at the Robert Bebb Herbarium at the University of Oklahoma (OKL).

PTERIDOPHYTA
Aspleniaceae
Asplenium platyneuron (L.) Britton, Sterns & Poggenb. – PEQR; P; CTH464

Dennstaedtiaceae
Pteridium aquilinum (L.) Kuhn – DAOF, PEQRF; P; CTH511

Dryopteridaceae
Onoclea sensibilis L. – WETL; P; CTH027
Polystichum acrostichoides (Michx.) Schott – ASQA, PEQR; CTH321
Woodsia obtusa (Spreng.) Torr. – ASQA; P; CTH475

Polypodiaceae
Pleopeltis polypodioides (L.) Andrews & Windham – PEQR; P; CTH109

Pteridaceae
Pellaea atropurpurea (L.) Link – PEQR; P; CTH071

CONIFEROPHYTA
Pinaceae
Pinus echinata P. Mill. – ASQA, PEQR; P; CTH520

MAGNOLIOPHYTA
MAGNOLIOPSIDA
Acanthaceae
Justicia americana (L.) Vahl – WETL; P; CTH062
Ruellia humilis Nutt. – DAOF; P; CTH022

Aceraceae
Acer rubrum L. – ASQA, PEQR; P; CTH441
Acer saccharum Marsh. – ASQA, PEQRF; P; CTH337

Anacardiaceae
Rhus aromatica Aiton – DAOF, PEQR; P; CTH070
Rhus copallinum L. – DAOF; P; CTH223
Rhus glabra L. – DAOF; P; CTH060
Toxicodendron radicans (L.) Kuntze – ASQA, DAOF, PEQRF, WETL; P; CTH543

Apiaceae
Ammoselinum butleri (Engelm. ex S. Wats.) Coult. & Rose – DAOF; A; CTH409
Chaerophyllum tainturieri Hook. – DAOF; A; CTH478
Cicuta maculata L. – WETL; P; CTH028
Eryngium prostratum Nutt. ex DC. – WETL; P; CTH163
Eryngium yuccifolium Michx. – PEQR ;P; CTH078
Ptilimnium capillaceum (Michx.) Raf. – DAOF; A; CTH370
Sanicula canadensis L. – ASQA; P; CTH054
Spermolepis inermis (Nutt. ex DC.) Mathias & Constance – DAOF; A; CTH085
Taenidia integerrima (L.) Drude – PEQR; P; CTH535
**Torilis arvensis* (Huds.) Link – DAOF; A; CTH091
Zizia aurea (L.) W.D.J. Koch – ASQA; P; CTH434

Apocynaceae
Amsonia tabernaemontana Walter – ASQA; P; CTH445
Trachelospermum difforme (Walter) A. Gray – WETL; P; CTH136

Aquifoliaceae
Ilex decidua Walter – ASQA, WETL; P; CTH224

Aristolochiaceae
+*Aristolochia serpentaria* L. – PEQR; P; CTH466

Asclepiadaceae
Asclepias quadrifolia Jacq. – ASQA; P; CTH487
Asclepias tuberosa L. – DAOF; P; CTH053
Asclepias variegata L. – ASQA, PEQR; P; CTH512
Asclepias verticillata L. – DAOF; P; CTH440

Asteraceae
Achillea millefolium L. – DAOF; P; CTH067
Ambrosia bidentata Michx. – DAOF; A; CTH263
Ambrosia psilostachya DC. – DAOF, PEQR; P; CTH318
Antennaria plantaginifolia (L.) Richardson – ASQA, PEQR; P; CTH411
Arnoglossum plantagineum Raf. – PEQR; P; CTH079
Astranthium integrifolium (Michx.) Nutt. – DAOFA; A; CTH465
Baccharis halimifolia L. – WETL; P; CTH348
Bidens aristosa (Michx.) Britt. – WETL; A; CTH335
Bidens discoidea (Torr. & A. Gray) Britt. – WETL; A; CTH272
Boltonia diffusa Ell. – WETL; P; CTH186
Brickellia eupatorioides (L.) Shinners – DAOF; P; CTH336

Chrysopsis pilosa Nutt. – DAOF; A; CTH153
Cirsium carolinianum (Walter) Fern. & Schub. – DAOF, PEQR; P; CTH019
**Cirsium vulgare* (Savi) Ten. – DAOF; A; CTH246
Conoclinium coelestinum (L.) DC. – WETL; P; CTH226
Conyza canadensis (L.) Cronq. – DAOF; A; CTH214
Coreopsis grandiflora Hogg ex Sweet – DAOF, PEQR; P; CTH527
Coreopsis palmata Nutt. – PEQR; P; CTH016
Coreopsis tinctoria Nutt. – DAOF, WETL; A; CTH069
Echinacea pallida (Nutt.) Nutt. – PEQR; P; CTH304
Eclipta prostrata (L.) L. – WETL; A; CTH309
Elephantopus carolinianus Raeusch. – ASQA; P; CTH236
Elephantopus tomentosus L. – ASQA; P; CTH252
Erechtites hieraciifolia (L.) Raf. ex DC. – ASQA, PEQR; A; CTH284
Erigeron pulchellus Michx. – DAOF; P; CTH450
Erigeron strigosus Muhl. ex Willd. – ASQA; A; CTH017
Erigeron tenuis Torr. & A. Gray – DAOF; P; CTH432
Eupatorium capillifolium (Lam.) Small – DAOF; P; CTH317
Eupatorium serotinum Michx. – DAOF, WETL; P; CTH267
Eurybia hemispherica (Alexander) Nesom – ASQA: P; CTH280
**Facelis retusa* (Lam.) Schultz-Bip. – DAOF; A; CTH493
Gamochaeta falcata (Lam.) Cabrera – DAOF; P; CTH048
Gamochaeta purpurea (L.) Cabrera – DAOF; A; CTH442
Helenium amarum (Raf.) H. Rock – DAOF; A; CTH004
Helianthus hirsutus Raf. – PEQR; P; CTH105
Helianthus tuberosus L. – DAOF; P; CTH380
Hieracium gronovii L. – PEQR; P; CTH437
Krigia dandelion (L.) Nutt. – ASQA; P; CTH486
Krigia caespitosa (Raf.) Chambers – DAOF; A; CTH303
Lactuca canadensis L. – DAOF; A; CTH198
Liatris squarrosa (L.) Michx. – DAOF, PEQR; P; CTH245
Mikania scandens (L.) Willd. – WETL; P; CTH142
Packera obovata (Muhl. ex Willd.) W. A. Weber & A. Love – AQSA; P; CTH
Pityopsis graminifolia (Michx.) Nutt. – PEQR; P; CTH258
Pluchea camphorata (L.) DC. – WETL;P; CTH256
Pseudognaphalium obtusifolium (L.) Hilliard & Burtt – DAOF; A; CTH326
Pyrrhopappus carolinianus (Walter) DC. – DAOF; A; CTH545
Rudbeckia grandiflora (D. Don) J.F. Gmel. ex DC. – DAOF, PEQR; P; CTH322
Rudbeckia hirta L. – DAOF; P; CTH094
Rudbeckia subtomentosa Pursh – ASQA: P; CTH277
Solidago hispida Muhl. ex Willd. – DAOF; P; CTH530
Solidago mollis Bartlett – DAOF; P; CTH529
Solidago nemoralis Aiton – PEQR; P; CTH531
Solidago petiolaris Aiton – ASQA; P; CTH333
Solidago rugosa P. Mill – DAOF; P; CTH323
Solidago ulmifolia Muhl. ex Willd. var. *microphylla* A. Gray – ASQA, PEQR; P; CTH160
**Sonchus asper* (L.) Hill – DAOF; A; CTH510
Symphyotrichum anomalum (Engelm.) Nesom – ASQA; P; CTH025

Symphyotrichum dumosum (L.) Nesom var. *dumosum* – DAOF; P; CTH360
Symphyotrichum patens (Aiton) Nesom var. *patens* – ASQA, PEQR; P; CTH285
**Taraxacum officinale* G. H. Weber ex Wiggers – DAOF; P; CTH416
Verbesina helianthoides Michx. – ASQA; P; CTH039
Vernonia baldwinii Torr. – DAOF; P; CTH266
Vernonia fasciculata Michx. – DAOF; P; CTH195
Vernonia lettermannii Engelm. ex A. Gray – WETL; P; CTH148

Balsaminaceae
Impatiens capensis Meerb. – WETL; P; CTH312

Berberidaceae
Podophyllum peltatum L. – ASQA; P; CTH477

Betulaceae
Carpinus caroliniana Walter – ASQA; P; CTH445
Corylus americana Walter – ASQA; P; CTH056
Ostrya virginiana (Mill.) K. Koch – ASQA, PEQR; P; CTH077

Bignoniaceae
Campsis radicans (L.) Seem. ex Bureau – DAOF, WETL; P; CTH076

Boraginaceae
Myosotis verna Nutt. – ASQA; A; CTH459

Brassicaceae
Arabis canadensis L. – PEQR; B; CTH046
**Capsella bursa-pastoris* (L.) Medik. – DAOF; A; CTH397
**Cardamine hirsuta* L. – DAOF; A; CTH415
Cardamine parviflora L. var. *arenicola* (Britton) O.E. Schulz – ASQA; A; CTH410
Draba brachycarpa Nutt. ex Torr. & A. Gray – DAOF; A; CTH418
Lepidium densiflorum Schrad. – DAOF; A; CTH434
Lepidium virginicum L. – DAOF; A; CTH170
**Sisymbrium officinale* (L.) Scop. – DAOF; A; CTH436
**Thlaspi arvense* L. – DAOF; A; CTH479

Buddlejaceae
Polypremum procumbens L. – DAOF; A; CTH259

Cabombaceae
+*Brasenia schreberi* J. F. Gmel. – WETL; P; CTH564

Callitrichaceae
Callitriche heterophylla Pursh – WETL; A; CTH472

Campanulaceae
Lobelia appendiculata A. DC. – DAOF; P; CTH365
Lobelia cardinalis L. – WETL; P; CTH227
Lobelia siphilitica L. – WETL: P; CTH242
Triodanis biflora (Ruiz & Pav.) Greene – DAOF; A; CTH305

Caprifoliaceae
Viburnum rufidulum Raf. – ASQA, PEQR; P; CTH554

Caryophyllaceae
**Cerastium glomeratum* Thuill. – DAOF; A; CTH412
**Cerastium pumilum* W. Curtis – DAOF; A; CTH461
Sagina decumbens (Ell.) Torr. & A. Gray – DAOF; A; CTH467
**Scleranthus annuus* L. – DAOF; A; CTH458
Silene virginica L. – ASQA; P; CTH481
**Stellaria media* (L.) Vill. – DAOF; A; CTH395

Chenopodiaceae
**Chenopodium pumilio* R. Br. – DAOF; A; CTH238

Cistaceae
Lechea tenuifolia Michx. – DAOF; P; CTH001

Clusiaceae
Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray – DAOF; A; CTH276
Hypericum hypericoides (L.) Crantz – ASQA, PEQR; P; CTH216
Hypericum mutilum L. – WETL; P; CTH247
Hypericum prolificum L. – ASQA; P; CTH253
Hypericum punctatum Lam. – DAOF; P; CTH167

Convolvulaceae
Dichondra carolinensis Michx. – DAOF; P; CTH093
Ipomoea pandurata (L.) G. Mey. – DAOF; P; CTH089

Cornaceae
Cornus florida L. – ASQA; P; CTH288
Cornus obliqua Raf. – WETL; P; CTH037
Nyssa sylvatica Marsh. – ASQA; P; CTH201

Cucurbitaceae
Melothria pendula L. – DAOF; P; CTH313

Cuscutaceae
Cuscuta cuspidata Englem. – DAOF; A; CTH319
Cuscuta indecora Choisy – DAOF; A; CTH369
Cuscuta pentagona Engelm. – DAOF; A; CTH183

Ebenaceae
Diospyros virginiana L. – DAOF, ASQA, PEQR; P; CTH129

Ericaceae
Vaccinium arboreum Marsh. – PEQR; P; CTH110
Vaccinium pallidum Aiton – PEQR; P; CTH033
Vaccinium stamineum L. – ASQA; P; CTH523

Euphorbiaceae
Acalypha monococca (Engelm. ex A. Gray) Lill. W. Mill. & Gandhi – DAOF; A; CTH257
Acalypha rhomboidea Raf. – DAOF; A; CTH050
Chamaesyce nutans (Lag.) Small – DAOF; A; CTH145
Croton capitatus Michx. – DAOF; A; CTH173
Croton glandulosus L. – DAOF; A; CTH212
Croton monanthogynus Michx. – DAOF; A; CTH158
Croton willdenowii G. L. Webster – DAOF; A; CTH199
Euphorbia corollata L. – DAOF; P; CTH233
Euphorbia longicruris Scheele – DAOF; A; CTH455
Euphorbia spathulata Lam. – DAOF; A; CTH456
Phyllanthus caroliniensis Walter – DAOF; A; CTH240

Fabaceae
Amorpha canescens Pursh – DAOF; P; CTH561
+*Amorpha ouachitensis* Wilbur – WETL; P; CTH522
Apios americana Medik. – WETL; P; CTH562
Baptisia bracteata Muhl. ex Ell. var. *leucophaea* (Nutt.) Kartesz & Gandhi – DAOF, PEQR; P; CTH426
+*Baptisia nuttalliana* Small – PEQR; P; CTH528
Cercis canadensis L. – ASQA, PEQR; P; CTH442
Chamaecrista nictitans (L.) Moench – DAOF; A; CTH133
Clitoria mariana L. – PEQR; P; CTH152
Crotalaria sagittalis L. – DAOF; P; CTH302
Dalea candida Michx. ex Willd. – DAOF; P; CTH088
Desmodium nuttallii (Schindl.) Schub. – ASQA; P; CTH354
Galactia volubilis (L.) Britt. – ASQA: P; CTH228
**Kummerowia stipulacea* (Maxim.) Makino – DAOF; A; CTH064
**Kummerowia striata* (Thunb.) Schindl. – DAOF; A; CTH208
Lathyrus venosus Muhl. ex Willd. – DAOF; P; H; CTH425
Lespedeza capitata Michx. – DAOF; P; CTH283
**Lespedeza cuneata* (Dum.-Cours.) G. Don – DAOF; P; CTH220
Lespedeza repens (L.) W. Bart. – PEQR; P; CTH306
Lespedeza violacea (L.) Pers. – DAOF; P; CTH265
Lespedeza virginica (L.) Britt. – DAOF, PEQR; P; CTH264
**Medicago lupulina* L. – DAOF; A; CTH308
Mimosa nuttallii (DC.) B. L. Turner – DAOF; P; CTH112
Orbexilum pendunculatum (P. Mill.) Rydb. – DAOF; P; CTH548
Rhynchosia latifolia Nutt. ex Torr. & A. Gray – DAOF, PEQR; P; CTH429
Robinia pseudoacacia L. – DAOF; P; CTH551

Sesbania herbacea (P. Mill.) McVaugh – WETL; A; CTH262
Strophostyles leiosperma (Torr. & A. Gray) Piper – DAOF; P; CTH111
Stylosanthes biflora (L.) Britton, Sterns & Poggenb. – DAOF; P; CTH207
Tephrosia virginiana (L.) Pers. – PEQR; P; CTH035
**Trifolium reflexum* L. – DAOF; P; CTH549
**Trifolium repens* L. – DAOF; P; CTH029
Vicia minutiflora F. G. Dietr. – ASQA; A; CTH422
**Vicia sativa* L. – DAOF; A; CTH430

Fagaceae
Quercus alba L. – ASQA, PEQR; P; CTH191
Quercus falcata Michx. – ASQA, PEQR; P; CTH204
Quercus marilandica Münchh. – PEQR; P; CTH126
Quercus nigra L. – ASQA; P; CTH490
Quercus phellos L. – ASQA; P; CTH131
Quercus rubra L. – ASQA, PEQR; P; CTH331
Quercus shumardii Buckl. – ASQA; P; CTH332
Quercus stellata Wangenh. – ASQA, PEQR; P; CTH292
Quercus velutina Lam. – ASQA, PEQR; P; CTH451

Geraniaceae
Geranium carolinianum L. – DAOF; A; CTH435

Grossulariaceae
+*Ribes cynosbati* L. – ASQA; P; CTH102

Haloragaceae
Myriophyllum heterophyllum Michx. – WETL; P; CTH500
Proserpinaca palustris L. – WETL; P; CTH482

Hamamelidaceae
Hamamelis vernalis Sarg. – ASQA; P; CTH421
Hamamelis virginiana L. – ASQA; P; CTH211
Liquidambar styraciflua L. – ASQA, WETL; P; CTH128

Hydrophyllaceae
Hydrolea ovata Nutt. ex Choisy – WETL; P; CTH194
Phacelia hirsuta Nutt. – DAOF; A; CTH454

Juglandaceae
Carya alba (L.) Nutt. ex Ell. – ASQA, PEQR; P; CTH443
Carya cordiformis (Wangenh.) K. Koch – ASQA; P; CTH544
Carya texana Buckl. – ASQA, PEQR; P; CTH351

Lamiaceae
Hedeoma hispida Pursh – DAOF; A; CTH300
**Lamium amplexicaule* L. – DAOF; A; CTH407

Lycopus virginicus L. – WETL; P; CTH018
Monarda fistulosa L. – ASQA, PEQR; P; CTH058
Monarda russeliana Nutt. ex Sims – ASQA; P; CTH516
Prunella vulgaris L. – ASQA, DAOF; P; CTH101
Pycnanthemum albescens Torr. & A. Gray – PEQR; P; CTH196
Pycnanthemum tenuifolium Schrad. – DAOF, WETL; P; CTH103
Salvia azurea Michx. ex Lam. – DAOF; P; CTH315
Salvia lyrata L. – ASQA, DAOF; P; CTH106
Scutellaria ovata Hill – ASQA; P; CTH082

Linaceae
Linum medium (Planch.) Britt. var. *texanum* (Planch.) Fernald – ASQA; P; CTH007
Linum striatum Walter – DAOF; A; CTH552

Lythraceae
+*Didiplis diandra* (Nutt. ex DC.) Wood – WETL; A; CTH499
Rotala ramosior (L.) Koehne – WETL; A; CTH175

Malvaceae
Callirhoe pedata (Nutt. ex Hook.) A. Gray – DAOF; P; CTH298
+*Modiola caroliniana* (L.) G. Don – DAOF; A; CTH462
Sida spinosa L. – DAOF; A; CTH161

Menispermaceae
Cocculus carolinus (L.) DC. – DAOF; P; CTH149

Molluginaceae
Mollugo verticillata L. – DAOF; A; CTH231

Monotropaceae
+*Monotropa hypopithys* L. – ASQA; P; CTH084

Moraceae
Morus rubra L. – ASQA; P; CTH169

Nymphaeaceae
Nuphar lutea (L.) Sm. – WETL; P; CTH080
Nymphaea odorata Aiton – WETL; P; CTH188

Oleaceae
+*Chionanthus virginicus* L. – ASQA; P; CTH488
Fraxinus americana L. – ASQA; P; CTH521

Onagraceae
Ludwigia decurrens Walter – WETL; P; CTH139
Ludwigia glandulosa Walter – WETL; P; CTH241
Ludwigia palustris (L.) Ell. – WETL; P; CTH182

Ludwigia peploides (Kunth) P.H. Raven – WETL; P; CTH250
Oenothera fruticosa L. – DAOF; A; CTH372
Oenothera laciniata Hill – DAOF; A; CTH492
Oenothera linifolia Nutt. – DAOF; A; CTH073

Oxalidaceae
Oxalis stricta L. – DAOF: P; CTH104
Oxalis violacea L. – PEQR; P; CTH314

Passifloraceae
Passiflora lutea L. – ASQA; P; CTH065

Phytolaccaceae
Phytolacca americana L. – DAOF; P; CTH143

Plantaginaceae
Plantago aristata Michx. – DAOF; A; CTH068
Plantago elongata Pursh – DAOF; A; CTH534
Plantago pusilla Nutt. – DAOF; A; CTH457
Plantago rhodosperma Dcne. – DAOF; A; CTH439
Plantago virginica L. – DAOF; A; CTH460

Platanaceae
Platanus occidentalis L. – WETL; P; CTH121

Polemoniaceae
Phlox pilosa L. ssp. *ozarkana* (Wherry) Wherry – ASQA; P; CTH429

Polygalaceae
Polygala alba Nutt. – DAOF, PEQR; P; CTH098

Polygonaceae
Polygonum hydropiperoides Michx. – WETL; P; CTH159
Polygonum lapathifolium L. – WETL; A; CTH138
Polygonum punctatum Ell. – WETL; A; CTH340
Polygonum scandens L. – WETL; P; CTH268
**Rumex crispus* L. – DAOF, WETL; P; CTH040
Rumex hastatulus Baldw. – DAOF; P; CTH423

Portulacaceae
Claytonia virginica L. – ASQA, DAOF; P; CTH400
Portulaca oleracea L. – DAOF; A; CTH180

Ranunculaceae
Anemone caroliniana Walter – ASQA; P; CTH413
+*Clematis crispa* L. – ASQA; P; CTH447
Clematis versicolor Small ex Rydb. – DAOF; P; CTH023

Ranunculus fascicularis Muhl. ex Bigelow – WETL; P; CTH441
Ranunculus hispidus Michx. – WETL; P; CTH408
Ranunculus micranthus Nutt. – WETL; P; CTH451
**Ranunculus parviflorus* L. – WETL; A; CTH020
Ranunculus pusillus Poir. – WETL; A; CTH362
Ranunculus recurvatus Poir. – WETL; P; CTH468

Rhamnaceae
Berchemia scandens (Hill) K. Koch – ASQA, DAOF; P; CTH057
Ceanothus americanus L. – PEQR; P; CTH044
Ceanothus herbaceus Raf. – DAOF, PEQR; P; CTH428
Frangula caroliniana (Walter) A. Gray – ASQA; P; CTH118

Rosaceae
Agrimonia rostellata Wallr. – ASQA; P; CTH237
Amelanchier arborea (Michx. f.) Fern. – PEQR; P; CTH123
Crataegus crus-galli L. – PEQR; P; CTH538
Crataegus marshallii Egglest. – ASQA: P; CTH484
Crataegus spathulata Michx. – ASQA, PEQR; P; CTH515
Crataegus viridis L. – WETL; P; CTH024
Geum canadense Jacq. – ASQA, DAOF; P; CTH563
Gillenia stipulata (Muhl. ex Willd.) Nutt. – ASQA; P; CTH514
Potentilla simplex Michx. – ASQA, DAOF; P; CTH452
Prunus mexicana S. Watson – ASQA, PEQR; P; CTH444
Prunus serotina Ehrh. – ASQA; P; CTH287
Rosa carolina L. – ASQA, DAOF; P; CTH524
Rubus allegheniensis Porter – DAOF; P; CTH553
Rubus ostryafolius Rydb. – DAOF; P; CTH032

Rubiaceae
Cephalanthus occidentalis L. – WETL; P; CTH150
**Cruciata pedemontana* (Bellardi) Ehrend. – DAOF; A; CTH496
Diodia teres Walter – DAOF: A; CTH219
Diodia virginiana L. – WETL; P; CTH433
Galium aparine L. – ASQA; A; CTH470
+*Galium arkansanum* A. Gray – ASQA; P; CTH045
Galium obtusum Bigelow – ASQA; P; CTH038
+*Houstonia ouachitana* (E.B. Sm.) Terrell – ASQA, PEQR; CTH566
Houstonia pusilla Schoepf – DAOF; A; CTH401
**Sherardia arvensis* L. – DAOF; A; CTH480

Rutaceae
Zanthoxylum clava-herculis L. – WETL; P; CTH450

Salicaceae
Salix caroliniana Michx. – WETL; P; CTH251
Salix nigra Marsh. – WETL; P; CTH125

Sapindaceae
Sapindus saponaria L. var. *drummondii* (Hook. & Arn.) L.D. Benson – DAOF; P; CTH125

Sapotaceae
Sideroxylon lanuginosum Michx. – PEQR; P; CTH232

Saxifragaceae
Heuchera americana L. – ASQA; P; CTH435

Scrophulariaceae
Gratiola brevifolia Raf. – WETL; P; CTH382
Lindernia dubia (L.) Pennell – WETL; A; CTH066
Nuttallanthus canadensis (L.) D.A. Sutton – DAOF: A; CTH437
Pedicularis canadensis L. – ASQA; P; CTH393
Penstemon arkansanus Pennell – PEQR; P; CTH433
Penstemon digitalis Nutt. ex Sims – DAOF; P; CTH525
**Verbascum thapsus* L. – DAOF; A; CTH072
Veronica peregrina L. – DAOF; A; CTH533

Solanaceae
Physalis pubescens L. – DAOF; A; CTH172
Solanum americanum P. Mill. – DAOF; P; CTH041
Solanum rostratum Dunal – DAOF; A; CTH134

Tiliaceae
Tilia americana L. – ASQA; P; CTH114

Ulmaceae
Celtis laevigata Willd. var. *reticulata* (Torr.) L.D. Benson – ASQA; P; CTH423
Ulmus alata Michx. – ASQA, PEQR; P; CTH127
Ulmus americana L. – ASQA; P; CTH356
Ulmus rubra Muhl. – ASQA; P; CTH130

Urticaceae
Boehmeria cylindrica (L.) Sw. – WETL: P; CTH135

Valerianaceae
Valerianella radiata (L.) Dufr. – DAOF; A; CTH010

Verbenaceae
Callicarpa americana L. – ASQA, PEQR; P; CTH137
Glandularia canadensis (L.) Nutt. – DAOF; P; CTH271
Verbena urticifolia L. – DAOF; A; CTH141

Violaceae
Viola bicolor Pursh – DAOF; A; CTH396
Viola pedata L. – ASQA, DAOF; P; CTH414
Viola sagittata Aiton – ASQA; P; CTH443
Viola sororia Willd. – ASQA, DAOF; P; CTH420

Vitaceae
Parthenocissus quinquefolia (L.) Planch. – DAOF; P; CTH144
Vitis aestivalis Michx. – DAOF; P; CTH185
Vitis cinerea (Engelm.) Engelm. ex Millard – DAOF; P; CTH539
Vitis rotundifolia Michx. – ASQA, PEQR; P; CTH210

LILIOPSIDA
Agavaceae
Manfreda virginica (L.) Salisb. ex Rose – PEQR; P; CTH327
Yucca glauca Nutt. – PEQR; P; CTH550

Alismataceae
Sagittaria platyphylla (Engelm.) J. G. Sm. – WETL; P; CTH026

Commelinaceae
Commelina virginica L. – ASQA; P; CTH361
Tradescantia ohiensis Raf. – ASQA; P; CTH012

Cyperaceae
Carex albicans Willd. ex Spreng. – ASQA, PEQR; P; CTH507
Carex arkansana (Bailey) Bailey – ASQA; P; CTH387
Carex bushii Mackenzie – ASQA; P; CTH505
Carex crinita Lam. – WETL; P; CTH385
Carex decomposita Muhl. – WETL; P; CTH386
Carex gravida Bailey – ASQA; P; CTH391
Carex hirsutella Mackenzie – WETL: P; CTH503
Carex hystericina Muhl. ex Willd. – WETL; P; CTH388
Carex lupulina Muhl. ex Willd. – WETL; P; CTH157
Carex lurida Wahlenb. – WETL; P; CTH383
+*Carex ouachitana* Kral, Manhart & Bryson – ASQA; P; CTH504
Carex texensis (Torr.) Bailey – ASQA, PEQR; P; CTH502
Carex tribuloides Wahlenb. – WETL: P; CTH384
Carex vulpinoidea Michx. – WETL; P; CTH506
Cyperus echinatus (L.) Wood – DAOF, PEQR; P; CTH230
Cyperus lupulinus (Spreng.) Marcks – DAOF; P; CTH428
Cyperus odoratus L. – DAOF; A; CTH274
Cyperus pseudovegetus Steud. – WETL; P; CTH051
Cyperus retrorsus Chapman – DAOF; P; CTH346
Cyperus strigosus L. – WETL; P; CTH560
Eleocharis lanceolata Fernald. – WETL; A; CTH295
Eleocharis montevidensis Kunth – WETL; P; CTH381

Eleocharis obtusa (Willd.) J. A. Schultes – WETL; A; CTH275
Eleocharis quadrangulata (Michx.) Roemer & J. A. Schultes – WETL; P; CTH146
Eleocharis tenuis (Willd.) J. A. Schultes var. *verrucosa* – WETL; A; CTH168
Fimbristylis autumnalis (L.) Roemer & J. A. Schultes – WETL; A; CTH347
Fimbristylis vahlii (Lam.) Link – WETL; A; CTH217
Isolepis carinata Hook. & Arn. ex Torr. – DAOF; A; CTH536
Rhynchospora globularis (Chapman) Small – DAOF; P; CTH363
Rhynchospora glomerata (L.) Vahl – DAOF; P; CTH260
Scirpus cyperinus (L.) Kunth – WETL; P; CTH165
Scirpus atrovirens Willd. – WETL; P; CTH432
Scleria oligantha Michx. – DAOF; P; CTH373

Dioscoreaceae
Dioscorea quaternata J. F. Gmel. – ASQA; P; CTH523

Hydrocharitaceae
Elodea canadensis Michx. – WETL: P; CTH509

Iridaceae
Sisyrinchium angustifolium P. Mill. – DAOF; P; CTH424

Juncaceae
Juncus acuminatus Michx. – WETL; P; CTH278
Juncus coriaceus Mackenzie – WETL; P; CTH184
Juncus diffusissimus Buckl. – WETL; P; CTH162
Juncus effusus L. – WETL; P; CTH154
Juncus interior Wieg. – DAOF; P; CTH427
Juncus marginatus Rostk. – WETL; P; CTH431
Juncus nodatus Coville – WETL; P; CTH425
+*Juncus repens* Michx. – WETL; P; CTH164
Juncus tenuis Willd. – ASQA, DAOF; P; CTH368
Luzula bulbosa (Wood) Smyth & Smyth – ASQA, DAOF; P; CTH471

Lemnaceae
Spirodela polyrrhiza (L.) Schleid. – WETL; P; CTH569

Liliaceae
Allium canadense L. – DAOF; P; CTH367
Allium stellatum Nutt. ex Ker-Gawl. – DAOF; P; CTH269
Camassia scilloides (Raf.) Cory – DAOF, PEQR; P; CTH473
Erythronium rostratum W. Wolf – ASQA; P; CTH419
Hypoxis hirsuta (L.) Coville – DAOF, ASQA, PEQR; P; CTH474
Nothoscordum bivalve (L.) Britt. – DAOF; P; CTH405

Najadaceae
Najas guadalupensis (Spreng.) Magnus – WETL; P; CTH497

Orchidaceae
Spiranthes tuberosa Raf. – WETL: P; CTH329

Poaceae
Agrostis hyemalis (Walter) Britton, Sterns & Poggenb. – WETL; P; CTH338
Agrostis perennans (Walter) Tuckerman – ASQA; P; CTH555
**Aira caryophyllea* L. – DAOF; A; CTH095
Andropogon gerardii Vitman – DAOF, PEQR; P; CTH222
Andropogon virginicus L. – DAOF; P; CTH345
Aristida oligantha Michx. – DAOF; A; CTH239
+*Brachyelytrum erectum* (Schreb. ex Spreng.) Beauv. – ASQA; P; CTH279
**Bromus arvensis* L. – DAOF; A; CTH436
**Bromus catharticus* Vahl – DAOF; A; CTH440
Bromus pubescens Muhl. ex Willd. – ASQA; P; CTH177
Chasmanthium latifolium (Michx.) Yates – ASQA, WETL; P; CTH147
Chasmanthium laxum (L.) Yates – ASQA, PEQR; P; CTH124
Cinna arundinacea L. – ASQA; P; CTH255
**Cynodon dactylon* (L.) Pers. – DAOF; P; CTH—061
**Dactylis glomerata* L. – DAOF; P; CTH374
Danthonia spicata (L.) Beauv. ex Roemer & J. A. Schultes – PEQR; P; CTH092
Dichanthelium aciculare (Desv. ex Poir.) Gould & C. A. Clark – DAOF; P; CTH371
Dichanthelium acuminatum (Sw.) Gould & C. A. Clark var. *fasiculatum* (Torr.) Freckmann – ASQA; P; CTH042
Dichanthelium boscii (Poir.) Gould & C. A. Clark – ASQA; P; CTH081
Dichanthelium dichotomum (L.) Gould var. *dichotomum* – ASQA, DAOF, PEQR; A; CTH176
Dichanthelium laxiflorum (Lam.) Gould – ASQA; P; CTH541
Dichanthelium linearifolium (Scribn. ex Nash) Gould – ASQA, PEQR; P; CTH074
Dichanthelium scoparium (Lam.) Gould – DAOF; P; CTH171
Dichanthelium sphaerocarpon (Ell.) Gould var. *isophyllum* (Scribn.) Gould & C.A. Clark – DAOF; P; CTH034
Dichanthelium villosissimum (Nash) Freckmann var. *praecocius* (Hitchc. & Chase) Freckmann – ASQA; P; CTH375
**Digitaria ischaemum* (Schreb.) Schreb. ex Muhl. – DAOF; A; CTH197
Digitaria sanguinalis (L.) Scop. – DAOF; A; CTH364
**Echinochloa crus-galli* (L.) Beauv. – WETL; A; CTH174
Elymus canadensis L. – DAOF, ASQA; P; CTH055
Eragrostis hirsuta (Michx.) Nees – DAOF; P; CTH031
Eragrostis intermedia A. S. Hitchc. – DAOF; P; CTH003
Eragrostis spectabilis (Pursh) Steud. – DAOF; P; CTH359
Festuca paradoxa Desv. – ASQA; P; CTH556
Gymnopogon ambiguus (Walter) Britton, Sterns & Poggenb. – DAOF; P; CTH281
Hordeum pusillum Nutt. – DAOF; A; CTH494
Leersia oryzoides (L.) Sw. – WETL; P; CTH341
**Lolium perenne* L. – DAOF; P; CTH519
+*Muhlenbergia bushii* Pohl – ASQA; P; CTH328
Panicum anceps Michx. – WETL; P; CTH202
Panicum dichotomiflorum Michx. – DAOF; P; CTH005

Panicum rigidulum Bosc ex Nees – DAOF, WETL; P; CTH379
Panicum virgatum L. – DAOF, WETL; P; CTH289
**Paspalum dilatatum* Poir. – DAOF; P; CTH011
**Paspalum notatum* Flueggé – DAOF; CTH261
Paspalum setaceum – WETL; P; CTH087
**Poa annua* L. – DAOF; A; CTH406
Schizachyrium scoparium (Michx.) Nash – PEQR; P; CTH221
Setaria parviflora (Poir.) Kerguélen – DAOF; P; CTH342
**Setaria viridis* (L.) Beauv. – DAOF; A; CTH209
Sorghastrum nutans (L.) Nash – DAOF, PEQR; P; CTH286
**Sorghum halepense* (L.) Pers. – DAOF; P; CTH052
Sporobolus cryptandrus (Torr.) A. Gray – DAOF; P; CTH557
Steinchisma hians (Ell.) Nash – WETL; P; CTH310
Tridens flavus (L.) A. S. Hitchc. – ASQA, DAOF, PEQR; P; CTH215
Tridens strictus (Nutt.) Nash – DAOF, PEQR; P; CTH320
Vulpia octoflora (Walter) Rydb. – DAOF; A; CTH008

Potamogetonaceae
Potamogeton diversifolium Raf. – WETL; P; CTH325
Potamogeton illinoensis Morong – WETL; P; CTH537
Potamogeton nodosus Poir. – WETL; P; CTH189

Smilacaceae
Smilax bona-nox L. – DAOF, ASQA, PEQR; P; CTH282
Smilax rotundifolia L. – DAOF, ASQA, PEQR; P; CTH099
Smilax tamnoides L. – ASQA, PEQR; P; CTH119

Typhaceae
Typha domingensis Pers. – WETL; P; CTH254

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THE TOXICITY OF EXTRACTS OF TEPHROSIA VIRGINIANA (FABACEAE) IN OKLAHOMA

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ABSTRACT

Historical usage of the roots of the legume *Tephrosia virginiana* as a piscicide by Native Americans has been documented. Due to questions about geographic variation in toxicity, an examination of the toxicity of six Oklahoma populations of the species was conducted. Rootstock extracts of plants in all populations exhibited acute toxicity in a standard laboratory bioassay using larval fathead minnows (*Pimephales promelas*). Isolation and identification of the compound or compounds responsible were not undertaken, however, toxicity is generally thought to be due to the presence of rotenone and related compounds. Although considerable variation in LC_{50} values exists among the six populations, this study produced few statistically significant differences. Correlations between plant toxicity and edaphic factors were not seen.

INTRODUCTION

Commonly known as hoary pea (Ibrahim 2000), goat's rue, catgut (Tyrl et al. 2008), and devil's shoestring (Swanton 1928), *Tephrosia virginiana* (Figure 1) is a member of the Fabaceae, or pea family. A native, perennial herb from woody rootstocks, it is distributed throughout the eastern half of the United States and extends westward to Iowa, and eastern Kansas, Oklahoma, and Texas (USDA-NRCS 2009). In Oklahoma it is most common in the eastern third, but can be found throughout the state. Populations are found in a variety of habitats in the Cross Timbers and prairies, with plants typically growing in sandy, well-drained soils (Tyrl et al. 2008). In addition, it is often associated with acidic soils (Steyermark 1963). Flowering time is from May to August, when the racemes of bicolored, papilionaceous flowers (Figure 2) produce legumes that are relished by wildlife (Tyrl et al. 2008).

Throughout most of its natural range, toxic compounds are absent in *T. virginiana* (Sievers et al. 1938), but in some populations, the roots contain the isoflavenoids rotenone, tephrosin, toxicarol, and other chemically similar compounds (Little et al. 1931). Rotenone is a well-known piscicide, exerting its toxic effects by blocking the oxidation of NADH and preventing ATP from being converted into usable cellular energy (Lindahl & Oberg 1961). Toxic populations occur in the southeastern states, and populations with the highest toxicity found thus far occur in the Carrizo Sands area of northeast Texas, an approximately 300-mile stretch from Caldwell County to Harrison County, where it widens out into Nacogdoches County to the east (Sievers et al. 1938). Previous tests on the plants of the species have revealed that the toxins are primarily sequestered in the underground portions. The seeds, however, have been found to contain rotenone, even in plants that were not otherwise toxic (Sievers et al. 1938).

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Figure 1 *Tephrosia virginiana* plant growing in Oklahoma. Photo courtesy of Ron Tyrl.

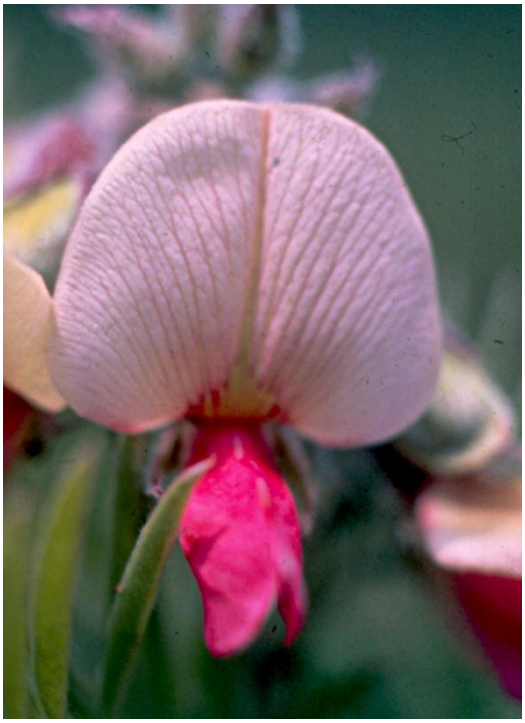

Figure 2 Individual flower of *Tephrosia virginiana* displaying a papilionaceous corolla. Photo courtesy of Ron Tyrl.

Historically, Native Americans in the Southeast (Florida, Tennessee, Mississippi, Alabama, and Georgia) used the roots of *T. virginiana* to stun fish to facilitate capture (Hudson 1976). The Cherokee, Creek, Seminole, Chickasaw, and Choctaw are documented as having used the plant. Among the first observers to report fishing with *T. virginiana* was James Adair, a Charleston trader, agent, and diplomat among the southeastern Indians of Mississippi from 1735 to 1768 (Hudson 1976). He observed that his Indian neighbors used plants to harvest fish in a process that was as much entertainment as labor.

> *In a dry summer season, they gather horse chestnuts and different kinds of roots, which having been thoroughly pounded pretty fine, and steeped a while in a trough, they scatter this mixture over the surface of a middle-sized pond, and stir it about with poles till the water is sufficiently*

impregnated with the intoxicating bittern (Williams 1930).

In 1906, Chitto Harjo, a Creek statesman, cited this activity in his famous plea that Creeks be allowed to "gather the wary fish" (Meserve 1933). Jennie Elrod (1924) of Oklahoma recorded in her diary that bound and dried *T. viginiana* roots were macerated and soaked in tubs of water overnight, and then scattered into a creek prior to a picnic (Figures 3 and 4). Numerous accounts of the plants being used in this manner include the writings of John Swanton, an ethnologist who studied the Creeks in the early 1900s. He wrote that among other plants used to stun fish, the devil's shoestring was used in pools isolated during the dry summer season. The roots were pounded directly on a hard surface, such as a fallen log, over the water surface to allow the juices to fall into the still pools or slow-flowing waterways (Swanton 1928). Following the relocation of the Indian tribes to Oklahoma in the 1830s, use of *T. virginiana* in fishing continued (Elrod 1924). As illustrated in a photographic atlas compiled in Oklahoma at the turn of the Twentieth Century, fishkills were a much-enjoyed sporting occasion until the practice was banned in 1915 (Gettys and Watkins 1984).

Despite these historical accounts of the apparent toxicity of *T. virginiana,* there are questions as to the toxicity of plants found in Oklahoma. In interviews recorded in *The Indian-Pioneer Papers* (Works Progress Administration 1937), Jefferson Berryhill, a member of the Muscogee (Creek) tribe, stated that roots from sandy areas (vs. rocky areas) were preferred and seemed to be "more virulent" in their poisoning abilities (Foreman 1938). Prior to this investigation, the most recent toxicity study involving Oklahoma populations of *T. virginiana* was conducted in the 1930s. Sievers and Russell (1938) investigated populations throughout the eastern United States and as far west as Oklahoma and Texas. They classified Oklahoma populations as "secondary" in nature, indicating that toxic plants were found infrequently in these populations and only under special circumstances. Specifically, they found that toxic plants occurred either in 'bald spots' where some factor, e.g., road construction or water erosion, had interfered with the normal development of the soil profile or sites where the roots of *T. virginiana* were in close proximity to those of other plants, especially oak roots. They considered these populations to be of little value for the commercial production of insecticide, an objective of their survey. Their observations thus contradict the historical accounts of fishkills by Native Americans in Oklahoma using *T. virginiana.*

Because of this apparent contradiction, this study was undertaken to investigate the toxicity of *T. virginiana* in Oklahoma. The work involved: (1) reviewing the literature of its historical use in Oklahoma; (2) locating Oklahoma populations; (3) collecting plants; (4) extracting from the rootstocks the compound or compounds responsible for toxicity; and (5) conducting bioassays for toxicity.

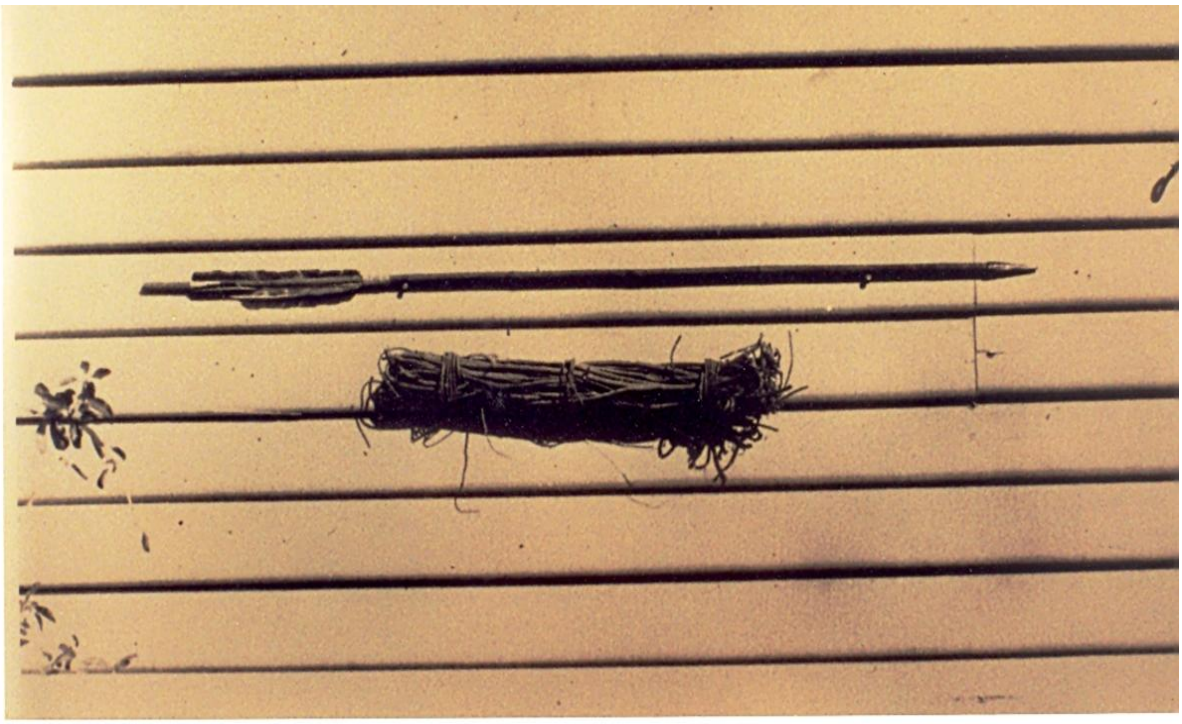

Figure 3 Bundled root of *Tephrosia virginiana* next to an arrow used in a fishkill in Okmulgee, Oklahoma, 1924. Photo by Jennie Elrod and courtesy of the Archives and Manuscripts Division of the Oklahoma Historical Society.

Figure 4 Creek tribesmen "going into the water with tubs of ground devil's shoestring, Aug 24, 1924", Okmulgee, Oklahoma. Photo by Jennie Elrod and courtesy of the Archives and Manuscripts Division of the Oklahoma Historical Society.

METHODOLOGY

Plant Collection

In order to examine the toxicity of *T. virginiana,* populations were located throughout the state using label information from herbarium specimens deposited in the OSU Herbarium (OKLA). During the 2007 growing season, the rootstocks (woody, underground stem base and/or root apex giving rise to aerial growth each season) of 3 or 4 plants were collected from each of six locations in five counties: Adair, Atoka, Cherokee, Okmulgee, and Osage (Figure 5; Table 1). As the plants were collected, surface soil samples also were collected. They were placed in paper bags and allowed to air dry for several weeks, after which they underwent routine tests for pH, organic matter (OM%), K index, P index, and soil texture at the Oklahoma State University Soil Water and Forage Analytical Laboratory (Stillwater, OK.).

Compound Extraction

Specimens were dried by placing them in paper bags at room temperature for two weeks. When completely dry, they were processed via a Soxhlet system using the protocol of Sievers and Russell (1938), which has long been used to extract toxic compounds from *Tephrosia.* This protocol was modified by the use of a SPEX® SamplePrep Freezer/Mill (SPEX® CertiPrep, Metuchen, NJ) to grind the dried roots cryogenically in order to prepare them for the extraction procedure. The freezer/mill was used due to the difficulty encountered during initial attempts to pulverize the long, tough lateral roots and woody rootstock.

All plant samples were ground to a fineness of #100 mesh using Tyler mesh sieves (Tyler Screening Company, Canada). Additional particle sizes used in the extraction were #20 and #200 mesh from the Beggs population in order to determine if root particle size would affect toxicity. Following the protocol of Sievers (1938), extracts were standardized to be equivalent to 1.5 g of ground sample per 100-mL of acetone solution in all samples. Rotenone is known to break down quite readily in water upon exposure to air and sunlight (Barnes and Freyre 1967). Therefore, using an acetone solution allowed for the quantification of sample as well as an extension of the natural shelf-life of the compounds. An acetone blank – a solution of acetone without any plant material included – was also used in the extraction as a control to rule out the toxic effects acetone may have had in the bioassay. All extracts were stored in a 25° C +/- 1° C (77° F +/- 1.8° F) room in foil-covered amber glass bottles between assays to reduce exposure to light.

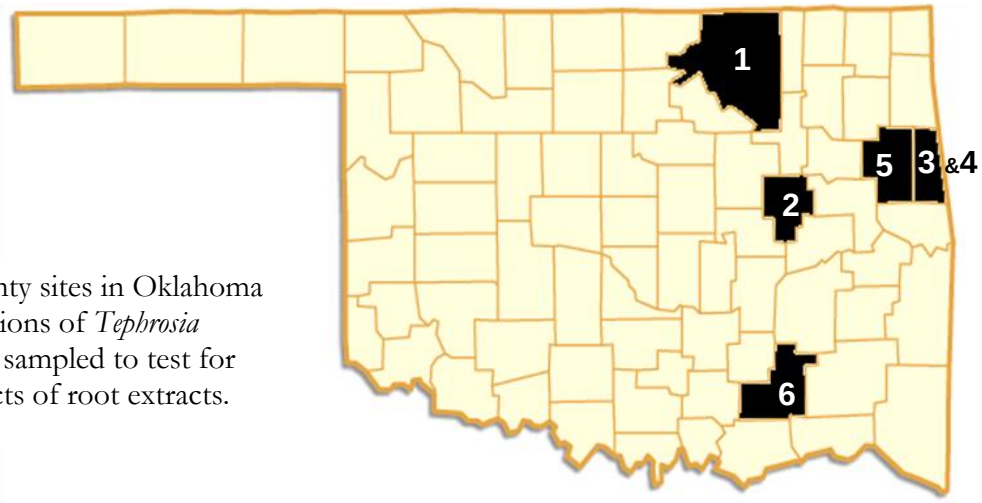

Figure 5 County sites in Oklahoma where populations of *Tephrosia virginiana* were sampled to test for piscicidal effects of root extracts.

Table 1 Locality information for sampling sites where *Tephrosia virginiana* specimens were collected in Oklahoma.

	Site name	County	GPS coordinates	Mileage	Habitat	Date collected	Ecological notes
1	Osage-Tallgrass Prairie Preserve (TGPP)	Osage	36°50'34.26"N 96°24'25.37"W	1km SE of TGPP HQ	on side of a large hill in a tallgrass prairie	05/22/07	evidence of burn earlier in the year (some stems were blackened); soils extremely rocky
2	Beggs	Okmulgee	35°44'24.59"N 96°01'08.81"W	near road cut off hwy 75; 2.5 km E of Beggs, OK	edge of fallow field under fence row	06/16/07	soil shallow and disturbed from erosion
3	Adair-Gittin'Down Mtn. (GDM)	Adair	35°45'57.31"N 94°43'50.68"W	approx. 1 km W of Bunch Rd. S of Hwy 100; 9.5 km SW of Stillwell, OK	understory of Oak-hickory forest on bluff above Charley Owl Cave	06/23/07	dense litter in area; limestone parent material; soil rocky; gently sloping topographic situation
4	Adair- Eagle Pass (EP)	Adair	35°42'48.00"N 94°32'05.96"W	Eagle Pass Hollow area near 'Jesus Saves' rock; N of county road E 0900; 4.5 km SE of Stillwell, OK	understory of Oak-Hickory forest on slope leading to Eagle Pass Creek	06/22/07	area burned in spring of collection year; steeply sloping topographic situation
5	Cherokee-Sparrowhawk Primive Area (SPA)	Cherokee	35°57'33.34"N 94°54'09.63"W	SPA about 1 km E of of Hwy 10 near Tahlequah, OK near the Illinois river	understory of Pine Oak hickory forest near mouth of SPA trail	09/15/07	limestone parent material; soil rocky; steeply sloping topographic situation
6	Atoka -Little Bugaboo Creek Overlook (LBCO)	Atoka	34°24'00.18"N 95°50'02.59"W	Near Little Bugaboo Canyon recreational overlook in McGee Creek State Park; 10 km SE of Atoka, OK	understory of mixed hardwood & Pine forest	10/25/07	dense litter in area; limestone parent material; soil rocky; nearly level topography

Laboratory Bioassays

Acute laboratory toxicity tests followed methods outlined in USEPA (2002) using the fathead minnow (*Pimephales promelas*) and were conducted under Oklahoma State University Animal Care and Use Protocol AS50110. Larval fish (<24 hours old) were exposed to dilutions (.01, 0.1, 1.0, and 10 mg/L) of plant extract in moderately hard (MH) formulated water (USEPA 2002). Additionally, two control test concentrations were used, the first consisting of an acetone blank solution (concentration of 10 mg/L in moderately hard formulated water), and the second of pure, moderately hard formulated water. All exposures were conducted in 250-mL glass bowls containing 200-mL of test solution, 10 fathead minnows per bowl, and two replicate bowls per test concentration. Test chambers were inspected every 24 h to determine the numbers of live and dead fish, with dead fish identified by discoloration and lack of response to gentle prodding. Test solutions were renewed every 24 h by replacing 80% of the water volume with freshly prepared extract solutions. Test temperature was maintained in a temperature controlled room at 25° C +/- 1° C (77° F +/- 1.8° F) with a 16/8 h light/dark cycle. Effects of Median Lethal Concentrations (48-hr LC_{50} values) were calculated using Comprehensive Environmental Toxicity Information System software (CETIS version 1.1.1, Tidepool Scientific Software, McKinleyville, CA). Tests were conducted as larval fish became available over a several month period beginning in July of 2007 and concluding in July of 2008. All samples were tested at least 4 times. Osage, Adair GDM, Beggs #20, and Beggs # 200 were tested 5 times each (Table 2).

Laboratory Water Chemistry

Temperature, dissolved oxygen (DO), pH, total ammonia, conductivity, alkalinity, and hardness were measured in each test solution at the start of each bioassay and at the beginning and end of each solution renewal cycle; pH was measured every 6 h throughout the tests. Ammonia was measured using an Accument® AR25 Ammonia Meter (Fisher Scientific, New Jersey, USA), with unionized ammonia concentrations estimated from the measured total values based on temperature and pH. Dissolved oxygen was measured using a YSI® model 550A Dissolved Oxygen meter (YSI Incorporated, Ohio, USA), and pH was measured using a Accument® portable AP62 pH/mV meter (Fisher Scientific, Pittsburg, Pennsylvania). Conductivity was measured with a Hach® conductivity/TDS meter (Hach, Loveland, Colorado), and alkalinity and hardness were measured by titration (APHA 1998). Prior to use, all water quality meters were calibrated according to the manufacturer instructions.

Statistics

Statistical tests for normality or heterogeneity of variance – Kruskal-Wallis One-WAY ANOVA on Ranks followed by Dunn's Post-hoc method – were performed to determine if any significant differences in 48-hr LC_{50} values existed between sample sites. Differences between the sites were regarded to be significant if $P < 0.05$. In addition, to determine the strength of the relationship between 48-hr LC_{50} values and various soil parameters, a simple linear regression was calculated and subsequently, a multiple linear regression. The regression equations were considered to be significant if the output $P < 0.05$.

RESULTS

Acute toxicity was observed in all samples tested, with the exception of the acetone blank and the pure MH water, where no mortality occurred. Because of the variability among the values generated from the replicate bioassays within sites (see

Table 2), there were few statistically significant differences in toxicity. Of these differences detected, the extracts from Adair Eagle Pass site and Atoka were significantly more toxic than the extract from Cherokee County ($P< 0.05$). The extract from Atoka was also significantly more toxic than the extract from Beggs. Some extracts varied in toxicity over time, with 48-hr LC_{50} values showing increases and decreases, whereas other extracts were more consistent (see Table 2). On average, the Cherokee sample was the least toxic, and Adair Eagle Pass and Atoka were found to have equivalent 48-hr LC_{50} values, as well as having the most consistent 48-hr LC_{50} values throughout the testing. Extracts from plant material that was ground finer (Beggs #200 mesh) exhibited the same toxicity as the standard particle size from the same collection site; plant material ground coarser (Beggs #20 mesh) exhibited higher average 48-hr LC_{50} values. These data are displayed in Figure 6, along with the standard deviation.

No relationships between toxicity and the five soil parameters examined – soil texture, pH, OM%, K index, or P index – were detected. The regression equations calculated were not significant.

Table 2 48-hr LC_{50} (mg/L) values for Fathead minnows (*Pimephales promelas*) exposed to root extracts of *Tephrosia virginiana* from different six sites in Oklahoma. An acetone blank and a pure water solution used as controls exhibited no toxicity.

	48-hr LC_{50} values (mg/L) (concentration lethal to 50% of fish within 48 hours)				
Location	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Beggs #20 mesh	0.32 (0.17-0.59)	0.79 (0.39-1.62)	1.58 (0.99-2.54)	1.00 (0.48-2.07)	1.00 (0.48-2.07)
Beggs #100 mesh	2.51 (C.I. NR)	2.51 (1.62-3.89)	-	2.51 (1.62-3.89)	2.51 (1.62-3.89)
Beggs #200 mesh	0.32 (C.I. NR)	3.16 (C.I. NR)	0.71 (0.43-1.16)	0.79 (0.39-1.62)	1.00 (0.48-2.07)
Adair Eagle Pass	0.32 (C.I. NR)	0.32 (C.I. NR)	-	0.32 (C.I. NR)	0.28 (C.I. NR)
Adair Gittin' Down Mtn.	2.80 (2.21-3.56)	1.0 (0.48-2.07)	1.12 (0.67-0.87)	1.26 (0.62-2.57)	2.51 (1.62-3.89)
Atoka	0.46 (0.31-0.7)	0.40 (0.26-0.62)	-	0.40 (0.26-0.62)	0.32 (C.I. NR)
Cherokee	4.62 (2.54-8.38)	3.16 (C.I. NR)	-	3.16 (C.I. NR)	2.51 (1.62-3.89)
Osage	0.30 (C.I. NR)	2.51 (1.62-3.89)	1.12 (0.67-0.87)	2.00 (1.11-3.57)	2.00 (1.11-3.57)
C.I. NR = unable to calculate reliable 95% confidence intervals					

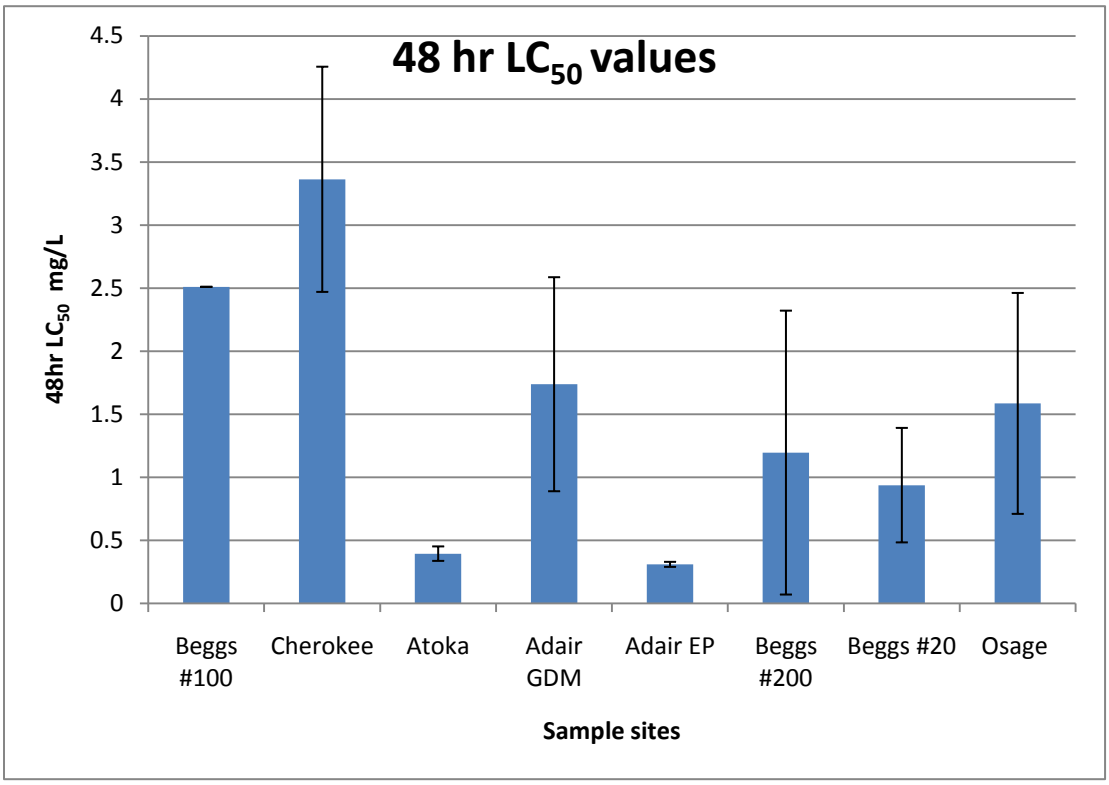

Figure 6 Mean 48-hr LC_{50} values and standard deviation bars for root extracts of *Tephrosia virginiana* from six sites in Oklahoma.

DISCUSSION

The six Oklahoma populations of *T. virginiana* tested in this study appear to contain a toxin (or toxins) that results in the mortality of fish in laboratory experiments. All extracts containing plant material produced mortality of larval fathead minnows in a standard laboratory bioassay (see Table 2; Figure 6). Because the objective of this preliminary study was to determine only if a toxin or toxins were present in Oklahoma populations, an attempt to isolate and identify the compound or compounds responsible was not undertaken.

The variability among the replicates within sites produced few statistically significant differences among the six populations (see Table 2). Degradation of the toxin or toxins with time is certainly a possibility (Barnes and Freyre 1967); however, there must be some persistance of the toxic compounds because Native Americans collected, dried, and stored the roots for varying lengths of time (Foreman 1938). A possible source of error is in the grinding process. Various portions of the rootstock might have been indiscriminately distributed in the particle size samples from Beggs collection site. It is not known if toxins are more prominent in the dermis or pith, for example, and this could have been a reason that particle size toxicity seemed to be uneven in relation to size .

Jefferson Berryhill's memory that roots from sandy area were preferred and seemed "more virulent" in their poisoning abilities (Works Progress Administration 1937; Foreman 1938) suggests that edaphic factors may play a role in toxicity of *T. virginiana.* Sievers and his coworkers (1938) likewise suggested that differences in toxicity might be related to soil and/or influences by other

plants. In this investigation, no relationships between toxicity and the five soil parameters examined were detected. However, because of the limited sample size and the variability in toxicity among the five populations, an understanding of the possible influence of edaphic influences requires that the preliminary work outlined here be repeated and extended.

ACKNOWLEDGMENTS

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FOUR WESTERN CHEILANTHOID FERNS IN OKLAHOMA

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Keywords: arid, distribution, habitat, key

ABSTRACT

The diversity of ferns in some of the more arid climates of western Oklahoma is surprising. This article examines four Oklahoma cheilanthoid ferns: *Astrolepis integerrima*, *Cheilanthes wootonii*, *Notholaena standleyi*, and *Pellaea wrightiana*. With the exceptions of *A. integerrima* and *P. wrightiana* which occur in Alabama and North Carolina respectively, all four species reach their eastern limits of distribution in Oklahoma. Included in this article are common names, synonyms, brief descriptions, distinguishing characteristics, U.S. and Oklahoma distribution, habitat information, state abundance, and a dichotomous key to selected cheilanthoids. The Oklahoma Natural Heritage Inventory has determined that all but one (*N. standleyi)* are species of concern in the state.

INTRODUCTION

Almost half of the ferns in the family Pteridaceae are xeric adapted ferns. In Oklahoma six genera and sixteen species in the family are known to occur. They live on dry or moist rocks and can be found in rock crevices, at the bases of boulders, or on rocky ledges. Common associated species include lichens, mosses, liverworts, and spike mosses. Two physical characteristics that unite the family are the marginal sori (Figure 1) and the lack of a true indusium. A sorus is a cluster of spore producing sporangia. A true indusium is a sterile flap of tissue that is either attached on the side or base of the sorus or the center or underneath the sorus (Figure 2). Five of the six genera have instead, false indusia formed by the revolute or reflexed margins of blade (Figure 3).

There are two families of ferns with genera in Oklahoma with both marginal sori and false indusia: the maidenhair fern, family Pteridaceae and the bracken fern *Pteridium*, in the family Dennstaedtiaceae. Bracken ferns are found in the pine forest of eastern Oklahoma, while most members of the Pteridaceae occur in western Oklahoma (Taylor & Taylor 1991).

Statewide, the most common species in the Pteridaceae is *Pellaea atropurpurea* (Figure 4), which can be found throughout the body of the state and Cimarron County in the panhandle. The rarest are *Cheilanthes horridula* and *Cheilanthes lindheimeri*. *Cheilanthes horridula* and *Cheilanthes lindheimeri* have only been seen in one county each, Murray and Comanche respectively. Descriptions and distributions of these two species have been previously addressed (Smith 2009).

The four cheilanthoids described in this article: *Astrolepis integerrima* (Figure 5); *Cheilanthes wootonii* (Figure 6); *Notholaena standleyi* (Figure 7); and *Pellaea wrightiana* (Figure 8), are well adapted to xeric habitats due to their small stature, leathery blades, false indusia, light colored surfaces, and their scaly, hairy or waxy surfaces. All these morphological features help conserve moisture (Moore 2007). Apogamous reproduction is another means by which cheilanthoids are adapted

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to live in xeric habitats. Sexual reproduction is not required, thus moisture is not required for "production of the sporophyte generation" (Wagner and Smith 1993).

All four species are found on more than one rock type. *Astrolepis integerrima* is known to occur on limestone rock in the Arbuckle Mountains (Figure 9); on granite rock in the Wichita Mountains (Figure 10); and on sandstone rock at Black Mesa (Figure 11). *Cheilanthes wootonii* is found in the Wichita Mountains, at Black Mesa, and also on red sandstone rock in the Caddo Hills (Figure 12). *Notholaena standleyi* and *Pellaea wrigtiana* are known to occur at Black Mesa and in the Wichita Mountains.

What makes these four species so interesting is their limited distribution, rarity, rocky habitats, and their morphologies that enable them to live in xeric habitats.

THE SPECIES

(FNA 1993; Tyrl et al. 2010; Hoagland et al. 2010; USDA-NRC 2010; Allison & Stevens 2001)

Astrolepis integerrima (Hook.) Benham & Windham
Long Cloakfern

Synonyms:
Cheilanthes integerrima (Hook.) Mickel
Notholaena integerrima (Hook.) Hevly
Notholaena sinuata (Lag. *ex* Sw.) Kaulf, var. *integerrima* Hook.

Description:
plants are perennials; from rhizomes
fronds all alike; blades 1-pinnately compound to pinnate-pinnatifid
stipe (petiole) brown
sori on margins
false indusia absent
pinnae oblong to ovate

Distinguishing Characteristics:
The absence of false indusia and presence of stellate to coarsely ciliate scales on adaxial blade surface

State Status: S1, critically imperiled species in Oklahoma with 5 or fewer occurrences or very few individuals or acres

U.S. Distribution: Alabama, Arizona, Nevada, New Mexico, Oklahoma, and Texas

Oklahoma Distribution: Cimarron, Comanche, Kiowa, and Murray counties

Cheilanthes wootonii Maxon
Beaded Lipfern

Synonyms: none

Description:
plants are perennials; from rhizomes
fronds all alike; blades 3-4-pinnately compound at the base
stipe (petiole) dark brown
sori on margins
false indusia formed by the revolute margins of the blade
pinnae lanceolate

Distinguishing Characteristic:
The glabrous adaxial surface and the costal scales on the abaxial surface that can obscure the ultimate segments

State Status: S2, imperiled species in Oklahoma with 6-20 occurrences or few remaining individuals or acres

U.S. Distribution: Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Texas, and Utah

Oklahoma Distribution: Canadian, Cimarron, Comanche, Greer, and Kiowa counties

Notholaena standleyi Maxon
Star Cloak Fern

Synonyms:
Cheilanthes hookeri (Kummel.) Domin
Cheilanthes standleyi (Maxon) Mickel

Description:
plants are perennials; from rhizomes
fronds all alike; blades pentagonal in outline; deeply pinnatifid
Scales absent on blades
stipe (petiole) brown
sori on margins
false indusia formed by the revolute margins of the blade

Distinguishing Characteristic:
Pentagonal blades with the white to cream to yellowish cream color on abaxial surfaces

State Status: Not a species of concern

U.S. Distribution: Arizona, Colorado, New Mexico, Oklahoma, and Texas

Oklahoma Distribution: Cimarron, Comanche, Greer, and Kiowa counties

Pellaea wrightiana Hook.
Wright's Cliffbrake

Synonym:
Pellaea ternifolia (Cav.) Link. var. *wrightiana* (Hook.) A. F. Tryon

Description:
plants are perennials; from rhizomes
fronds all alike; blades 2-pinnately compound at the base
stipe (petiole) dark brown
sori on margins
false indusia formed by the revolute margins of the blade
pinnae with 3-9 ultimate segments (pinnules)

Distinguishing Characteristic:
Apices of pinnules mucronate

State Status: SH, historically known species from Oklahoma, but possibly extirpated; not seen in 15

U.S. Distribution: Arizona, Colorado, New Mexico, North Carolina, Oklahoma, Texas, and Utah

Oklahoma Distribution: Cimarron, Comanche, Greer, Johnston, Kiowa, Murray, and Ottawa counties

CONCLUSION

Because they are classified as rare and limited in their distribution, conservation of habitats for these four species is important. We are fortunate in Oklahoma to have state parks, state resort parks, and wildlife refuges which conserve these species by conserving habitat. In your search for these ferns, I encourage you to use regional manuals and field guides as well as *Keys and Descriptions for the Vascular Plants of Oklahoma* (Tyrl et al. 2010). When using a key to identify ferns, it is important to use a good glossary of terms. If you don't have one you can use online resources such as *Pteridophytes of Wisconsin: Ferns and Fern Allies* (Fewless 2010).

I hope readers will keep the Oklahoma Biological Survey informed on the status of these four species, including *Notholaena standleyi*. If and when you find these species, take good photos, record accurate location information, and send the photos and location information to Oklahoma Biological Survey (www.biosurvey.ou.edu). I know they will appreciate it.

ACKNOWLEDGEMENTS

Thanks to the editorial board for their advice, and encouragement. Thanks also to Falls Creek Baptist Assembly, Great Plains State Park, the Hoot Owl Ranch, Camp Canyon and Conference Center, Quartz Mountain Resort Park, and Red Rock Canyon State Park for allowing me to access their properties for photographs. I would also like to thank the staff at the Bebb Herbarium for allowing me to view their specimens. A final thanks to my wife Sharon and Richard Butler for their assistance.

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KEY TO THE CHEILANTHOID FERNS OF CANADIAN, CIMARRON, COMANCHE, GREER, JOHNSTON, KIOWA, AND MURRAY COUNTIES OF OKLAHOMA

This key includes the four western cheilanthoids discussed in the article plus eight additional species. The key is designed to enable the reader to make a positive identification of the four target species, only in the counties where the four species have been reported. It is important to remember that the other eight species can be found outside of these seven counties. They have been included in this key to allow the reader to make a positive identification on the four species that this article has targeted.

1. Blades pentagonal or deltoid in outline; abaxial surfaces covered by white to cream to yellowish waxy powder, otherwise glabrous.
   2. Blades pentagonal in outline; simple pinnatifid. ..... *Notholaena standleyi*
   2. Blades deltoid in outline; 3- to 5-pinnately compound. ..... *Argyrochosma dealbata*
1. Blades of various shapes, but not pentagonal or deltoid in outline; abaxial surfaces of blades green in color or obscured by abundant hairs or scales.
   3. Adaxial surfaces of blades with scabrous pustulose (broad-based) hairs ..... *Cheilanthes horridula*
   3. Adaxial surfaces of blades glabrous or of various pubescence, but not having scabrous pustulose hairs.
      4. Blades 1-pinnately compound. ..... *Astrolepis integerrima*
      4. Blades 2- to 4-pinnately compound.
         5. Rachis and costal scales absent.
            6. Abaxial surfaces of blades glabrous or with a few scattered hairs along major veins.
               7. Abaxial surfaces of blades glabrous; apices conspicuously mucronate. Rachis glabrous. Stipes dark brown. ..... *Pellaea wrightiana*
               7. Abaxial surfaces of blades with a few scattered hairs along major veins; apices obtuse to slightly mucronate. Rachis with segmented hairs Stipes reddish purple to black. ..... *Pellaea atropurpurea*
            6. Abaxial surfaces of blades pubescent.
               8. Blades 3-pinnate at base; abaxial surfaces densely pubescent. ..... *Cheilanthes feei*
               8. Blades 2-pinnate-pinnatifid at base; abaxial surfaces sparsely pubescent. ..... *Cheilanthes lanosa*
         5. Rachis and costal scales present.
            9. Adaxial surfaces of blades glabrous or appearing to be tomentose. Costal scales on abaxial surfaces often concealing ultimate segments.
               10. Adaxial surfaces glabrous. Revolute margins on abaxial blade surfaces conspicuous..... *Cheilanthes wootonii*
               10. Adaxial surfaces appearing to be tomentose. Revolute margins on abaxial blade surfaces not conspicuous ..... *Cheilanthes lindheimeri*
            9. Adaxial surfaces pubescent. Costal scales on abaxial surfaces not concealing ultimate segments.
               11. Rachis and costal scales lanceolate to ovate, conspicuous. ..... *Cheilanthes eatonii*
               11. Rachis and costal scales linear and inconspicuous. ..... *Cheilanthes tomentosa*

Figure 1 Marginal sori, *Pellaea atropurpurea* (all photos by author)

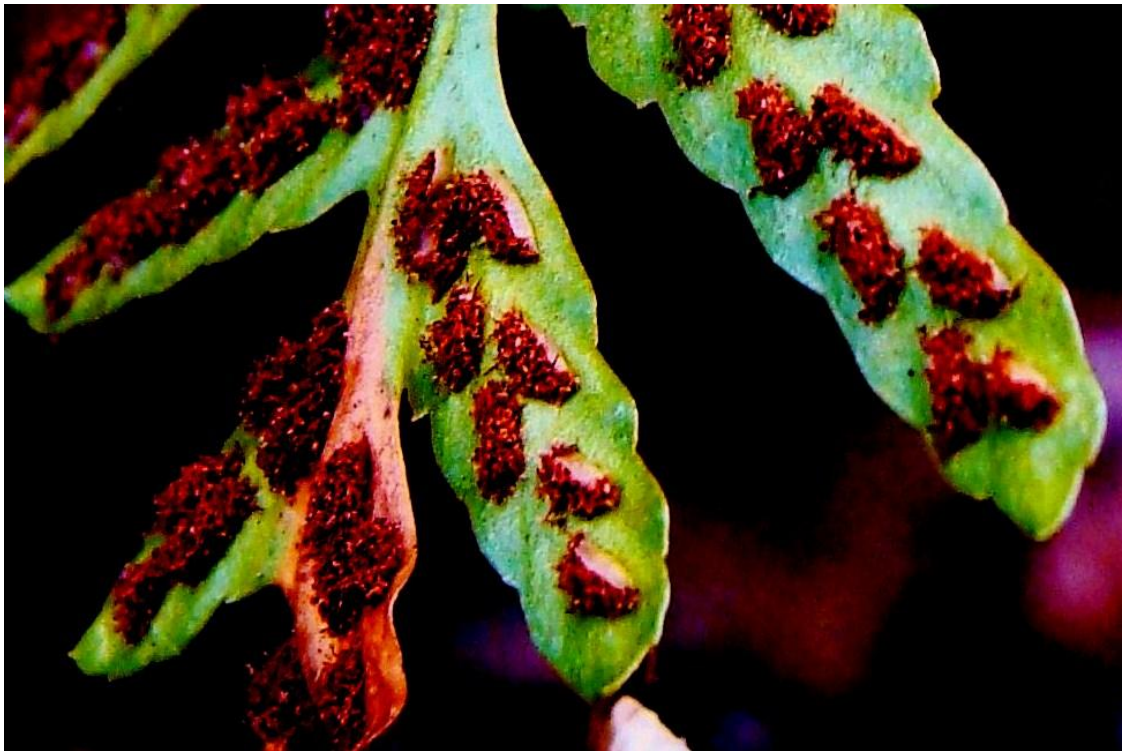

Figure 2 True indusia attached along the sides of the sori, *Asplenium* (spleenwort)

Figure 3 False indusium, *Cheilanthes wootonii*

Figure 4 *Pellaea atropurpurea*, the most common species of pteridaceae in the Oklahoma.

Figure 5 *Astrolepis integerrima* on limestone rock in the Arbuckle Mountains

Figure 6 *Cheilanthes wootonii* growing on sandstone rock in Cimarron County

Figure 7 *Notholaena standleyi* growing on granite rock in the Wichita Mountains

Figure 8 *Pellaea wrightiana* growing on granite rock in Great Plains State Park

Figure 9 Limestone rock in the Arbuckle Mountains

Figure 10 Granite rock at Quartz Mountain Resort Park in the western part of the Wichita Mountains.

Figure 11 Sandstone rock on the Hoot Owl Ranch in Cimarron County (Black Mesa area)

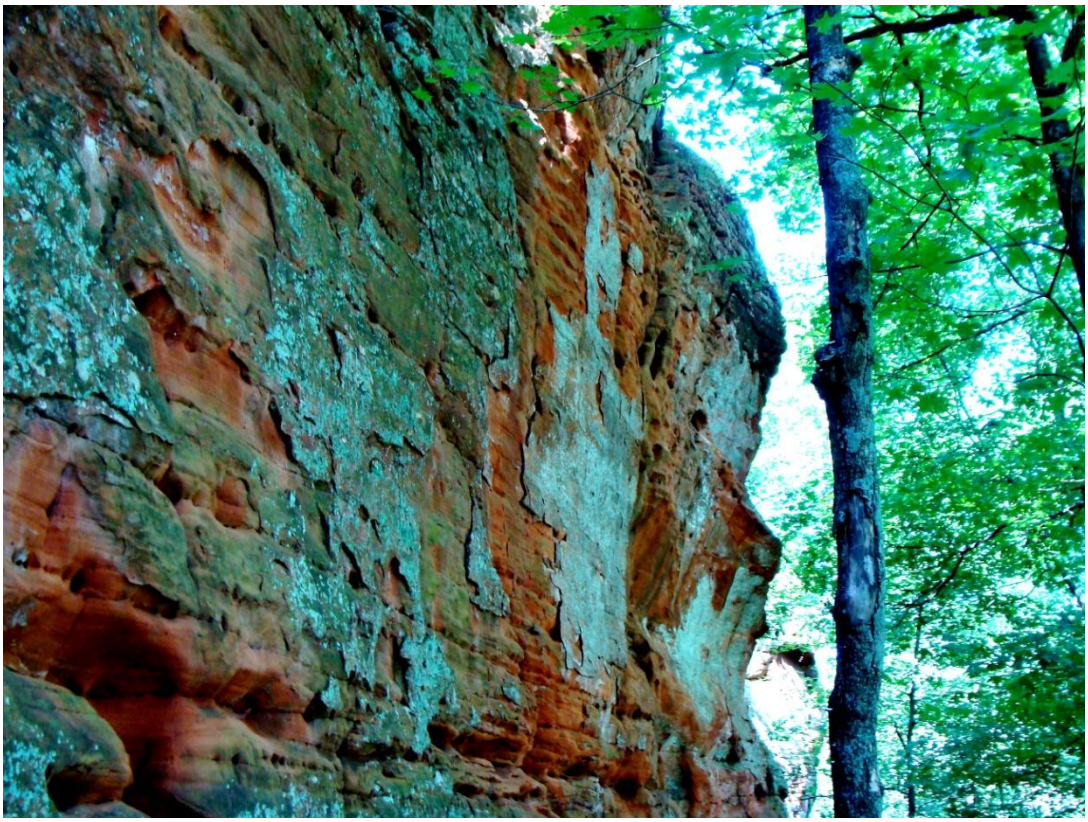

Figure 12 Red sandstone rock in the Caddo Hills

"BEING A METHOD PROPOSED FOR THE READY FINDING…TO WHAT SORT ANY PLANT BELONGETH"

Ronald J. Tyrl
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As any ONPS member will attest, it doesn't take many field trips into the prairies and forests of Oklahoma to encounter an unknown plant and have to ask, "What is it?" The easiest way to identify it is disarmingly simple; ask someone who knows! This approach works well when an *expert* is near at hand, ready to name plants. A second approach is to compare the unknown plant with photographs or illustrations in field guides specific for Oklahoma. Unfortunately, the major drawbacks in using such guides are that they typically illustrate only showy-flowered species and may not include all species present in the area. The ideal way to identify an unknown plant is to use a taxonomic key – an artificial analytical device for identification which offers a progressive series of choices between pairs of alternative features (Lawrence 1951). Taxonomists have been writing and using them for centuries as they have inventoried the world's flora (Voss 1952). Go anywhere in the world and if a taxonomic key is available, unknown plants can be identified.

Even after more than 45 years of working as a plant taxonomist, I still take pleasure in the challenge of identifying a totally unknown plant, i.e., one that I have no inkling of what it is. It is a delight to sit down at a dissecting microscope with dissecting needles in hand, to examine the plant's many features, to revel in its beauty and complexity, and to work my way through the key to arrive, eventually, at a species name. Sometimes my first try is successful, but more often I have to make several or even numerous attempts. However, nothing is more satisfying than to be able to say "Gotcha! I know who you are!" In the following essay, I offer an overview of the origins and evolution of taxonomic keys, aspects of their nature, and suggestions on how to use them successfully.

Origins and Evolution of the Key—
Taxonomic keys have been the mainstays of plant identification for more than 250 years. Their origins, however, are considerably older and can be traced to the classifications of Aristotle and Theophrastus, based on *fundamentum divisionis* or the "principle of division" and those of 17th Century naturalists (Voss 1952; Stuessy 1990). Edward G. Voss, a plant taxonomist and former Curator of the Herbarium at the University of Michigan, published an excellent, comprehensive history of taxonomic keys in 1952. It was a delight to have discovered this paper many years ago, and I have excerpted aspects of it in the following very abbreviated summary. Voss describes how taxonomists such as Robert Morison, John Ray, Augustus Rivinus, and the anatomist Nehemiah Grew presented their classifications (1672, 1686, 1699, and 1682, respectively) in a tabular outline form and used brackets to relate and contrast their groups (essentially diagrams of relationships; Figure).

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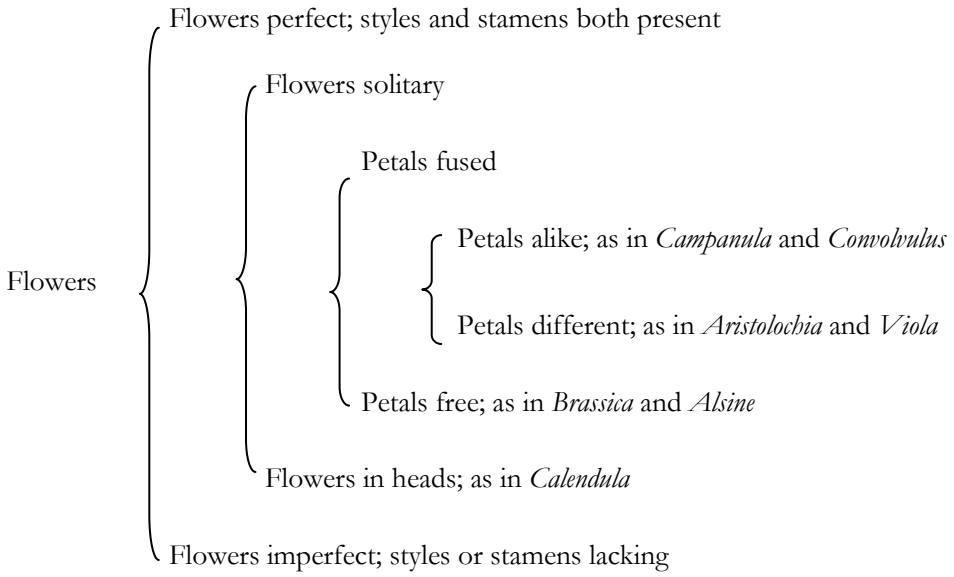

Figure A portion of the classification of John Ray appearing on page 20 of Volume 1 of his *Historia Plantarum* (1686), showing his groups and the brackets used to relate them. Latin text of Ray's groups translated and abbreviated.

I must stress that these bracketed tables were not keys and their purpose was not identification, but rather classification. As Voss notes, Grew, however, did articulate the idea of using a dichotomous key to identify plants. An appendix to the second part of book four of his *Anatomy of Plants* (1682) is titled "Being a Method proposed, for the ready finding, by the Leaf and Flower, to what Sort any Plant belongeth." In it, he describes how one might go about identifying an unknown plant and lists characteristics of the leaves and flowers that should be used in its identification. It was suggested that his title would be a catchy opening for this essay, and thus I have unabashedly used it.

Although Carolus Linnaeus, typically known as the father of taxonomy, apparently used *clavis,* the Latin word meaning "key," to describe these bracketed diagrams in his 1736 edition of *Bibliotheca Botanica,* the famous French naturalist and early proponent of the theory of evolution, Jean Baptiste de Lamarck, is generally credited with the development and first publication of the strictly dichotomous keys specifically for identification purposes. He used them throughout his *Flore Francoise* published in 1778. Francis Arthur Bather (1927; cited in Voss 1952), in an address to the Geological Society of London, described the significance of Lamarck's keys in biology by stating:

> *A key is not a classification, but a method of analysis. The idea was first explicitly brought forward by Lamarck at the very beginning of his career. Having asserted that every species of French plant could be more readily determined by a purely arbitrary analytic key than by the Linnean system with its mixture of supposed reality and ordered arbitrariness he was challenged to produce such a key, and this he did within twelve months…*

Since the time of Lamarck, keys have been an essential part of biological endeavor and used for the identification of all living systems. They are now an integral part of the literature of taxonomy, ecology, and indeed any discipline dependent upon plant identification, e.g., range management, wildlife biology, and conservation. Keys for the identification of plant families, genera, and species typically are incorporated in floristic treatments known as floras or manuals. These

works are designed to facilitate identification of the plants in an area and generally comprise the keys, descriptions of the morphology of each taxonomic group, and abbreviated comments about each group's distribution, ecology, flowering time, and taxonomic relationships. Please remember that the word "flora" also is used as a collective noun for all of the plants in an area, i.e., the botanical equivalent of fauna.

Nature of a Key—But what is a key? It is simply a device that presents its user (you) with a progressive series of choices between pairs of alternative, generally mutually exclusive features. For example, you might be asked to examine your unknown plant and to decide whether it is a *tree* OR an *herb*. Selection of the applicable alternative character state leads you to other pairs of alternative character states, e.g., *petals yellow* OR *petals white* or *leaves simple* OR *leaves compound,* and ultimately to the unknown plant's scientific name. Using a key is thus analogous to following a forking path with each fork forming a "Y". To reach the proper destination, i.e., identification of the unknown plant, you must take the correct path (choose the applicable character state) at each fork. I liken a key to a Victorian maze with its numerous forking paths among screens of boxwood or hazel. Correct choices made at each fork lead one to the center or exit. For example, a key to five Oklahoma species might read as follows:

1. Plants trees.
   2. Leaves opposite; venation palmate. Fruits double samaras. ..... *Acer rubrum* (red maple)
   2. Leaves alternate; venation pinnate. Fruits nuts partially enclosed in involucral caps (acorn). ..... *Quercus stellata* (post oak)
1. Plants herbs.
   3. Inflorescences umbels. Leaves alternate. Corollas rotate. Ovaries inferior. ..... *Polytaenia nuttallii* (prairie parsley)
   3. Inflorescences panicles or racemes or spikes. Leaves opposite. Corollas bilabiate. Ovaries superior.
      4. Stems square. Inflorescences spikes. Fruits nutlets. ..... *Prunella vulgaris* (heal-all)
      4. Stems terete. Inflorescences panicles or racemes. Fruits capsules. ..... *Penstemon oklahomensis* (Oklahoma beardstongue)

The pair of alternative features at each fork is termed a couplet, and the alternatives of a single couplet are called leads or legs. To facilitate use of the key, the couplets typically are successively indented to the right, with both leads of a single couplet equally indented and generally numbered. After observing the unknown plant's features, you commence keying at couplet 1 by reading both leads and making a decision as to which lead applies. After one of the two leads has been selected, you proceed to the first indented couplet immediately under it. The couplets under the non-selected lead are disregarded because the features listed aren't those of your unknown plant. You continue reading the leads of successive couplets, observing the plant's features, and making choices until a scientific name is reached.

Thus, using the key above, if you observe that your unknown plant is an herb with terete stems, opposite leaves, panicles, bilabiate corollas, superior ovaries, and capsules, you identify it as _?_ (see the last paragraph of this essay to check your identification). I have to admit that a glossary of taxonomic terms is indeed handy to have available when you first begin keying. Technical descriptive terms–the bane of beginners–are essential to ensure accuracy and brevity. However, the more you use a key, the more familiar the terms will become, and your reliance on the glossary will quickly decline.

Types of Keys—The key presented above is an indented key, so named because each successive couplet is indented to the right. In contrast, a bracketed key has couplets that are not indented but rather you are directed to the appropriate succeeding couplet via a number at the right-hand margin. The leads of each couplet are always together. Use of a bracketed key is the same as for an indented key and involves observing the plant's features, reading both leads, and making a choice. A bracketed key to the same five species appears below.

1. Plants trees. 2
1. Plants herbs. 3
2. Leaves opposite; venation palmate. Fruits double samaras. ..... *Acer rubrum* (red maple)
2. Leaves alternate; venation pinnate. Fruits nuts partially enclosed in involucral caps (acorn). ..... *Quercus stellata* (post oak)
3. Inflorescences umbels. Leaves alternate. Corollas rotate. Ovaries inferior. ..... *Polytaenia nuttallii* (prairie parsley)
3. Inflorescences panicles or racemes or spikes. Leaves opposite. Corollas bilabiate. Ovaries superior. 4
4. Stems square. Inflorescences spikes. Fruits nutlets. ..... *Prunella vulgaris* (heal-all)
4. Stems terete. Inflorescences panicles or racemes. Fruits capsules. ..... *Penstemon oklahomensis* (Oklahoma beardstongue)

Thus if you observe that your unknown plant is an herb with alternate leaves, umbels, rotate corollas, and inferior ovaries, you will identify it as _?_ (see the last paragraph of this essay to check your identification).

As is obvious, the bracketed key saves considerable space because the couplets are not indented to the right with the lines of text getting shorter. However, using it is time-consuming. Every couplet must be read in order, it is harder to locate succeeding couplets, and it is harder to retrace one's previous decisions. In an indented key, you quickly skip the couplets that are not applicable and have a better overview of what decisions you have made previously. As you become familiar with more plants and see their names in the couplets, you develop a sense of whether you are on the "right" path in identifying your unknown plant.

Branching by repeatedly forking into pairs of mutually exclusive leads (choices), indented and bracketed keys are termed dichotomous keys (from the Greek *dicho* meaning "in two" or "split"). Choosing between only two character states is perhaps an innate part of the human intellect. We tend to like true and false questions, we cheer the teams of the Superbowl, and we label movies good or bad. We therefore feel comfortable using dichotomous keys. However, taxonomic keys written in the 1800s and early 1900s were not always strictly dichotomous. Some authors occasionally included trichotomous, tetrachotomous, and even pentachotomous couplets. As you might expect, the third, fourth, and fifth alternatives might easily be overlooked thus leading to errors in identification of the unknown plant. Fortunately, the dichotomous key has become the standard.

Indented and bracketed keys are also known as single-entry or single-access keys in that they have a single starting point – the character or characters of couplet 1. There is just one route or sequence of characters leading to the identification of an unknown plant. If one or more characters appearing in the couplets of the key are not available to the user, identification of an unknown plant becomes more difficult and sometimes impossible. An alternative to the dichotomous key is the multiple-entry or multiple-access key. Also known as a polyclave or polyclave key, the multiple-entry key, as its name suggests, allows the user to select the

characters used to identify an unknown plant from a character set that describes the plants of an area or taxonomic group such as family or genus. Initially, these character sets were tables or charts with plant names forming a matrix with a list of many different character states. The names of species not possessing the features of the unknown plant at hand were crossed out until only one name remained. A polyclave key to the five species previously appearing in the indented and bracketed keys is given below.

	Penstemon oklahomensis	*Prunella vulgaris*	*Acer rubrum*	*Polytaenia nuttallii*	*Quercus stellata*
Plants trees	-	-	+	-	+
Plants herbs	+	+	-	+	-
Stems terete	+	-	+	+	+
Stems square	-	+	-	-	-
Leaves opposite	+	+	+	-	-
Leaves alternate	-	-	-	+	+
Venation palmate	-	-	+	-	-
Venation pinnate	+	+	-	+	+
Inflorescences umbels	-	-	-	+	-
Inflorescences panicles	+	-	-	-	-
Inflorescences racemes	+	-	+	-	-
Inflorescences spikes	-	+	-	-	-
Corollas rotate	-	-	-	+	-
Corollas bilabiate	+	+	-	-	-
Ovaries superior	+	+	+	-	-
Ovaries inferior	-	-	-	+	+
Fruits double samaras	-	-	+	-	-
Fruits nuts	-	-	-	-	+
Fruits nutlets	-	+	-	-	-
Fruits capsules	+	-	-	-	-

If you observe that your unknown plant is an herb with square stems, opposite leaves, spikes, bilabiate corollas, superior ovaries, and nutlets; you will identify it as _?_ (again, see the last sentence of this essay to check your identification).

As you will note, your unknown plant can be identified by a single character. As you

might expect, however, identification by inspection in a polyclave key becomes harder as the number of species and the number of characters increase. In reality, seldom will a single character state be sufficient to identify an unknown. Thus, the process of progressive elimination was subsequently simplified by the use of cards with "windows" inserted at various points or their edges punched or notched to reflect different characters and character states. Each card represented a single species. The cards were stacked (in any order) and then retained or eliminated depending upon the character state appearing in the "window" or punched/notched edge until a single card remained and identification was thus accomplished (Hansen and Rahn 1969; Jones and Luchsinger 1986).

Although polyclave keys appeared as early as the 1930s, it was not until the 1960s that they became widely used (Morse 1971). In the late 1960s and early 1970s, taxonomists began to use computer-punched cards in place of the window or notched-edge cards (Pankhurst 1974). The advent of computers and the ability to incorporate and manipulate a plethora of characters, character states, and species greatly expanded the use of polyclave keys and today all use computer algorithms (Simpson 2006). Two approaches are employed in these computer-assisted keys. One is essentially a computerized version of the punch card system with species being eliminated by their incorrect character states when compared to the unknown plant. The second is slightly different in that it employs probabilities or likelihood ratios to indicate the species that have been eliminated and those likely to match the unknown (Jones and Luchsinger 1986).

Successful Use of a Key—Although a taxonomic key looks intimidating at first, its use is quite easy. For individuals who have not used one before, the following suggestions are offered.

- When attempting to identify an unknown plant, you should use, whenever possible, the keys appearing in a flora written specifically for your area or state. Examples of such books are George Goodman's (1958) *Spring Flora of Central Oklahoma* and *Keys and Descriptions for the Vascular Plants of Oklahoma* (Tyrl et al. 2010). The latter is a precursor to the *Flora of Oklahoma* which is being written by a consortium of state botanists. If a local flora is not available, a regional (*Flora of the Great Plains* 1986) or continental (*Flora of North America North of Mexico* 1993+) treatment can be used. Remember my earlier statement about being able to go anywhere in the world and if a key is available, unknown plants can be identified? Keys are available for just about everywhere!
- Before beginning to key, spend a few moments becoming familiar with your unknown plant. Look at characters such as those cited in the keys given above. Dissect a flower or two. You will find that keying is typically faster and easier if you have many of the plant's features already in mind.
- Always read both leads of a couplet and, if necessary, again observe the plant carefully before making a decision as to which lead best describes your unknown plant. Although the first lead of a couplet may be applicable, the second may be better.
- Sometimes the leads of a single couplet will be separated by numerous other couplets. Use the numbers at the beginning of the leads to locate them.
- Be sure that you read each lead carefully and fully understand it. In the indented and bracketed keys given above, note that the different characters in the leads are separated by periods; whereas, semicolons are used to separate different states of one character, and commas are used for clarity. In other keys, semicolons are used to separate characters, and commas are used to separate character states.

- Be sure that you understand the meanings of the terms used in each couplet. Use a glossary; most manuals have one.
- Be as careful and accurate as possible in making your observations. Use a magnifying lens to observe (and discover the beauty of) smaller features of the plant's surfaces, flowers, and fruits. Use a ruler to measure widths and lengths accurately; don't estimate. Sometimes the difference between two species is just a few millimeters.
- Whenever possible, do not base your selection of a lead on a single observation. Always try to examine more than one leaf or flower or fruit or surface. Remember that plants are living systems and as such sometimes vary in their features. For example, one flower may have four petals whereas all the others have five, or a normally alternate-leaved plant may have an occasional node with opposite leaves.
- When the name of a family, genus, or species is reached in the key, you should compare the features of the unknown plant with the group's morphological description in a manual and, if available, a botanical illustration. If they match, identification is accomplished. If they don't match, you should reexamine the features of the unknown plant and begin keying again. Be sure to, again, carefully read both leads of each couplet before selecting one.
- You undoubtedly will, at some point, encounter a couplet for which the selection of a lead is tenuous. When this happens, you should follow both leads and their following couplets. When you arrive at your two "answers," read the descriptions of both groups in order to determine which best describes your unknown plant. Often, the key will "tell you" whether you have selected the appropriate lead. If the subsequent couplets pose leads that are totally inapplicable to your unknown, it is likely that you have chosen the wrong lead and you need to return to the original couplet and take the other lead.
- You also will likely encounter a couplet that cites a character that your unknown plant does not have, e.g., fruits or roots. Just ignore it and rely on the other characters listed in the couplet, or again follow both leads as described above.

Satisfaction—As I stated at the beginning of this essay, I find it most satisfying to be able to say to an unknown plant, "I now know who you are!" I hope that someday you will have that same feeling of satisfaction.

With respect to possibly your first keying experiences, were you successful in identifying the three unknown plants? Based on the characters listed (your observations), the first unknown plant you keyed was *Penstemon oklahomensis,* a species endemic to the state that flowers from April to June and is characteristic of the mid to late stages of plant succession in prairies. The second unknown plant was *Polytaenia nuttallii*, a member of the Apiaceae or carrot family, and typically is encountered as scattered plants or small populations in dark loamy or clay soils of Oklahoma's prairies. The third unknown plant was *Prunella vulgaris*, a member of the Lamiaceae or mint family, and generally encountered as individual plants or small populations in the moist soils of partially shaded forests or woods throughout the eastern half of the state.

Best wishes for your future keying experiences!

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