TAXONOMIC AND ETHNOBOTANICAL INVESTIGATIONS OF THE VASCULAR FLORA OF OKLAHOMA

By

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CHAPTER I

ORGANIZATION OF THESIS

This thesis consists of three parts each of which encompasses various aspects of plant taxonomy. Plant taxonomy is one of the oldest, if not the oldest, disciplines of science, with evidence of its origins in the earliest writings of recorded history (Arber, 1912). Throughout time, the discipline has evolved to encompass more than just identifying plants. Taxonomy has five operational goals or objectives (Mason, 1950). The primary goal of the five is to provide an inventory of the world's flora. This inventory can be local, regional, or global in scale. Chapter 2 presents the results of such a study — a floristic inventory of three tracts of the Ozark Plateau National Wildlife Refuge in Adair County, Oklahoma.

The second operational goal of taxonomy is to provide a system of categories. As our observations and understanding of plant features have evolved, so have our classification systems. We now focus on phylogeny as a means of determining relationships among categories. The third goal of taxonomy is to provide a means of documentation. This aspect of the discipline deals with specimen preservation and verification of taxonomic concepts. It is accomplished by plants: (1) being collected, dried, mounted on archival paper, and placed in an herbarium; (2) being grown in botanical gardens; and (3) being illustrated, photographed, or described using standard

phytographic terms. The specimens collected in the Ozark Plateau National Wildlife Refuge and deposited in the Oklahoma State University Herbarium are illustrative of this goal of taxonomy. Likewise, the floristic treatment of the genus *Eragrostis* — comprising keys for identification and morphological descriptions for all species of the genus in Oklahoma — presented in Chapter 3 reflect this goal.

The fourth operational goal is to provide a system of names for plant taxa. The system that has evolved is embodied in *the International Code of Botanical Nomenclature*, (McNeill et al., 2006). The fifth and final objective of taxonomy is to elucidate biological processes. Understanding biological, ecological and evolutionary processes in plant groups is considered the data gathering phase of taxonomy and is sometimes called biosystematics (Mason, 1950). The final chapter of this thesis, an investigation of the toxicity of the native legume *Tephrosia virginiana*, is a biosystematic endeavor.

As noted above, this thesis comprises three parts, each of which encompasses one component of the research conducted between 2006 and the present. Chapters 2 and 4 are written in the format of traditional scientific papers; it is anticipated that they will be submitted for publication in the *Proceedings of the Oklahoma Academy of Science* or similar journals. The format of Chapter 3 follows that of the Editorial Committee of the Flora of Oklahoma Project and will be incorporated in the *Flora of Oklahoma* and preceding publications.

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CHAPTER 2

A FLORISTIC SURVEY OF THREE TRACTS (SALLY BULL HOLLOW, EAGLE PASS AND WORKMAN MTN.) OF THE OZARK PLATEAU NATIONAL WILDLIFE REFUGE, ADAIR COUNTY, OKLAHOMA

ABSTRACT

Four hundred forty-two species of vascular plants in 285 genera and 88 families were encountered in a two-year floristic inventory of the Eagle Pass, Sally Bull Hollow, and Workman Mountain tracts of the Ozark Plateau National Wildlife Refuge and the adjoining Ozark Plateau Wildlife Management Area, which encompass 1772-ha in Adair County, Oklahoma. Ninety-two percent of the species were native and the largest families were Asteraceae, Fabaceae and Poaceae, together constituting 33% of the total taxa present in the three tracts. Eighty-five species collected were new records for Adair County. Nineteen species designated as rare by the Oklahoma Natural Heritage Inventory (OHNI) were encountered: *Dryopteris filix-mas, Tradescantia ozarkana, Uvularia grandiflora, Corallorhiza odontorhiza, Diarrhena americana, Elymus hystrix, Impatiens pallida, Arabis shortii, Desmodium pauciflorum, Castanea pumila* var. *ozarkensis, Dicentra cucullaria, Montropa uniflora, Clematis virginiana, Rosa woodsii, Houstonia ouachitana, Agalinis tenuifolia, Tilia americana, Urtica chamaedryoides, and Vitis mustangensis.*

INTRODUCTION

Initially known as The Oklahoma Bat Caves National Wildlife Refuge, the Ozark Plateau National Wildlife Refuge (OPNWR) was established in April, 1986 to protect several cave-dwelling species, including the Ozark cavefish (*Amblyopsis rosae*) and the Ozark big-eared bat (*Corynorhinus townsendii ingens*), as well as migratory bird species. The refuge currently consists of eight tracts of land in Adair, Delaware, and Ottawa Counties in Oklahoma, and efforts to further expand its boundaries are ongoing. Recognition that protection of the refuge's cave-dwelling species also requires protection of the habitat surrounding the caves has led the United States Fish and Wildlife Service (USFWS) to employ an ecosystem approach (Christensen et al., 1996; Grumbine, 1994; USFWS, 2002). Maintaining populations of native plant species in situ is an integral facet of habitat protection, thus there is a critical need for a thorough knowledge of the plants and vegetation present in order to facilitate effective management of the area by USFWS personnel and those of the cooperating Oklahoma Department of Wildlife Conservation (ODWC).

Floristically, Oklahoma's entire Ozark Region (Ozark Highlands and Boston Mountains Level III Ecoregions; Woods et al., 2005) unfortunately is markedly under-surveyed. Illustrative of this lack of knowledge is that the only general survey of the region is a doctoral dissertation completed by Charles Wallis (1959) in the 1950s. Bruce Hoagland (2000) pointed out that the Ozark Plateau warranted further investigation when he published his Regional Vegetation Classification System for Oklahoma. Inventory of the vascular plants present in the OPNWR began in 2001. Charriss Hayes was commissioned by the USFWS to compile an inventory of the refuge's Sally Bull Hollow Tract in Adair County (Hayes, 2003). Although Wallis (1959) collected 328 species in Adair County, no specimens were collected within the boundaries of

the present refuge. Thus Hayes' work is the beginning of the ongoing efforts described in this report. Subsequent to Hayes' work in Sally Bull Hollow, adjoining parcels of land known as the Eagle Pass and Workman Mtn. tracts were incorporated into the refuge under the authority of the ODWC. Personnel of both agencies coordinate the supervision of the tracts, with common management goals (ODWC, 2005).

In 2006, a two-year survey of these two tracts plus continued exploration of Sally Bull Hollow was initiated. The objectives of this work were four: (1) to compile a list of the species present in each tract; (2) to estimate the relative abundance of each species; (3) to provide, using GPS coordinates, the geographical locations of the species listed as "rare" by the Oklahoma Natural Heritage Inventory (2006); and (4) to prepare herbarium voucher specimens documenting the species present.

TRACT CHARACTERISTICS

The three tracts — Sally Bull Hollow, Eagle Pass, and Workman Mtn. — form a unit of 1845-ha in eastern Adair County approximately 7.2 km southeast of the town on Stillwell (Figure 1). The population density of Adair County is 14 individuals per km² (U.S. Census Bureau, 2000). The tracts lie between 35° 45'N and 35 °41'N latitudes and 94°33'W and 94°29'W longitudes, and are situated in the Boston Mou ntains Level III Ecoregion (Woods et al., 2005). The Boston Mountains area is the highest and most rugged section of the Ozark Region in Oklahoma (Unklesbay & Vineyard, 1992). Topographically, it comprises mountain ridges and saddles separated by narrow valleys known locally as hollows. Elevation ranges from 270 m to 512 m. Karst features such as caves and sinkholes are common. The area

bedrock has been weathered away by seasonal torrential rains developing into fast-flowing spring and creek systems (Goodman, 1977). These waterways carve steep ravines as springs well up from the creek beds. Seeps are common on the sloping hillsides. This terrain coupled with the higher precipitation rates are thought to make the Ozarks one of the most floristically diverse places in the state (Hoagland, 2000).

The Soil Conservation Service (1965) characterized the area as having mainly Atoka sandstone of Pennsylvanian age with some Cotter dolomite alluvium of early Ordovician age forming surface rocks. These rocks are overlain by terrace and alluvial deposits of Quaternary age. Stream dissection has cut deep valleys through the narrow belt of rugged topography and several major drainage lines run with a northeasterly trend parallel to the fault blocks (Curtis et al. 1979). Soils found in the various areas of the refuge are of the Hector complex, Etowah-Greendale, or the Hector-Linker associations. The Hector soils are shallow, acidic, sandy or stony lithosols, and are by far the major soil type in the refuge. The Linker soils are on nearly level to moderately sloping mountaintops and are deep, fine sandy loams with few sandstone fragments in the surface layers and found only associated with the Hector soils. Etowah-Greendale soils are found in creek beds in conjunction with talus from cherty limestone and contain large amounts of gravel. Overall runoff is rapid to excessive.

The Oklahoma Climatological Survey (2008) describes Adair County's climate as warm-temperate with cool winters and hot humid summers. Average annual precipitation ranges from about 127 cm to nearly 137 cm throughout the county. May and June are the wettest months, on average, but this tapers gradually towards early spring and fall. Nearly every winter has at least 2.5 cm of snow, with 67% of years having 25 or more cm. Temperatures average near 15℃, with a slight increase from north to south. Tempe ratures range from an average daytime

high of 31℃ in July to an average low of 3 degrees C in January. The growing season averages 192 days, but plants that can withstand short periods of colder temperatures often have an additional four to eight weeks of growth. Significant daily temperature discrepancies within the refuge are due to the varied topography. Winds from the south to southeast are quite dominant, averaging nearly 12 km-per-hour. Relative humidity, on average, ranges from 44% to 95% during the day.

The vegetation of the area is characterized as a dense oak-hickory deciduous forest (Bruner, 1931; Hoagland, 2000). Fifteen forest associations are present in addition to the associations correlated with the valley streams and disturbance. A variety of herbaceous understory species are present (Hayes, 2003). Fire history of the refuge is largely unknown (Steve Hensley, OPNWR manager, personal communication), but within this study, observations were made of scattered fires within the tracts and the following was noted: (1) fires burned at low intensities, and were patchy in nature; (2) understory layers of detritus and duff were consumed while canopy and subcanopy layers were essentially undamaged; (3) fires seemed to occur at varying intervals and be of varying sizes, and they seemed to burn until extinguished by locals or die out naturally. Overall, fire seemed to be a sporadic and natural part of the ecosystem in the refuge, doing little damage to trees and clearing away much of the previous year's litter.

Eagle Pass Tract:

Encompassing 517-ha, this tract is the southernmost portion of the area surveyed (Figure 1). Its terrain contains both north and south facing escarpments formed by an east-west meandering ridge system bordering branches of spring-fed creeks in the valley known as

Eagle Pass. A good deal of the tract is hilly, but there are some flat, upland areas sufficiently large enough to permit growth of xeric woodlands with patchy open canopies. The area is currently 90% forested, but was logged to an unknown extent in the past (Hensley, personal communication). Numerous cave entrances are found within the limestone ridges. The tract contains some highly disturbed areas in the form of debris and trash dumps and ATV paths winding across the upland areas. Disturbance also occurs adjacent to paved county road D0900RD that dissects the tract, as well as former logging sites in both the upland and lowland areas.

Workman Mountain Tract:

This 518-ha tract is somewhat similar to the Eagle Pass Tract in that the terrain is quite steep, but also contains some gentler slopes as well. The headwaters of Indian Creek are a prominent feature. In the tract's upland areas, disturbance due to free-range livestock grazing has occurred. The topography of the tract is characterized mainly by the north-south lying Workman Mountain, but east-west running ridges and valleys form the slopes of the upland area. County road D4771RD dissects the tract.

Sally Bull Hollow Tract:

Hayes (2003) described this 810-ha tract as comprising two meandering ridges extending from the northeast to the southwest separated by a narrow valley (the hollow) in which a spring-fed, intermittent stream flows. The ridge tops are approximately 200 m above

the valley floor. Numerous escarpments are present, as are numerous entrances to an extensive network of caves.

METHODOLOGY

This floristic survey was conducted during the growing seasons — early March through late October — of 2006 and 2007. Eight trips were made at three- to four-week intervals, and a total of 71 man-days were expended on the endeavor. Each tract was surveyed on foot by one or more individuals, following compass bearings in the cardinal directions and using topographic maps (USGS, 1:24,000). Often the survey involved following the north-south or east-west meandering ridges found in each tract, and at periodic intervals exploring the slopes by going downhill at right angles to the ridges, moving laterally, and then returning uphill to the ridge tops. In addition, the topographic maps were continually examined and areas with different or unusual topographic features specifically explored. In this way, all areas of the three tracts were systematically traversed. As different habitats were encountered, the species and ecological conditions present were recorded.

Floristic surveys are by their very nature subjective exercises, since they involve a purposeful search for interesting or unique habitats (Palmer et al., 1995; 2002; 2007). Therefore, an attempt was made to explore each tract thoroughly in order to encounter and survey as many different habitats as possible. The purpose of this intentional search for many diverse habitats was to encounter as many species as possible (Palmer et al., 2002). Subsequently, a list of the species present in each tract was compiled. Ecological information, including names of associated species, was incorporated in herbarium labels.

Two herbarium voucher specimens in fertile condition were collected and prepared using standard herbarium techniques (Womersley, 1981). One voucher was deposited in the Oklahoma State University Herbarium (OKLA) and the other laminated and given to refuge personnel. Species deemed 'rare' because their populations comprised one or just a few individuals were not collected, but instead were simply listed as being present in a particular location. Likewise, taxa listed as S1, S2, or S3 by the ONHI (2006) were not collected, but rather simply recorded as present. Some species were listed as sight records only. They included abundant, easily recognized dominant species in sterile condition, e.g., *Quercus stellata*, or commonly encountered exotic weeds such as *Lespedeza cuneata* or *Sorghum halepense.*

As each habitat in the three tracts was encountered, the dominant species present were noted. Their relative abundance was noted using a five category system — abundant, frequent, occasional, infrequent, and rare — developed by Palmer and coworkers (1995). At the conclusion of all fieldwork, all rankings were re-evaluated. At the same time, associated species and observations of the site's ecological features were recorded for subsequent inclusion in herbarium label information. In addition to this information, the habitats were classified using Hoagland's Vegetation Classification System (2000).

Plants encountered that were not immediately recognized were identified using taxonomic keys, taxonomic descriptions, and herbarium specimens (Waterfall, 1969; Correll & Johnston, 1970; Tyrl et al., 2007). Taxa normally were identified only to species, with the exception of *Cuscuta* sp., which was only encountered in sterile condition. Infraspecific taxa of eleven species were identified in order to determine whether they were cited as "rare" by ONHI (2006).

Of particular interest were species listed as “rare” in Adair County by the OHNI (2006). This inventory ranks a species’ rarity at both state (S) and global (G) levels on a scale of 1-5. A ranking of 1 designates a plant as being critically imperiled (5 or fewer sites of occurrence or very few remaining individuals or acreage); 2 if it is imperiled (6-20 occurrences or few individuals or acreage remaining); 3 if it is rare and local in its range (or found locally in a restricted range with 21-100 sites); 4 if apparently secure, but may be quite rare in parts of its range, especially at the edges; and 5 if demonstrably secure, however it may be quite rare at the distributional limits of its range (ONHI, 2006). Additionally, a listing of ‘T’ means the plant is threatened. Locations of rare species in the three tracts were recorded using GPS coordinates and mapped on USGS topographic maps (scale 1:24,000).

Scientific nomenclature, common names, and designation as a native or introduced species follow that of the PLANTS Database (USDA NRCS, 2009), with the exception of *Carex aureolensis* Steudel, which does not appear in the database. Nomenclature in this case follows Tyrl et al. (2007).

FLORA OF THE SALLY BULL HOLLOW, EAGLE PASS, AND WORKMAN MOUNTAIN TRACTS OF THE OZARK PLATEAU NATIONAL WILDLIFE REFUGE

Floristic summary

In this study, 442 vascular species in 285 genera and 88 families were collected or recorded as present in the three tracts of the OPNWR (Table 1; Appendix I). As is apparent, the flowering plants dominate with 86 monocot and 343 dicot species. Only

two conifer and eleven fern species were encountered. The Poaceae (41 species), Asteraceae (68 species), and Fabaceae (37 species) constituted 33% of the flora. The largest genera present were *Quercus* (10 species), *Carex* (10 species), *Viola* (7 species), *Plantago* (6 species), and *Lespedeza* (6 species).

Table 2.1 Taxa encountered in this study of the Sally Bull Hollow, Eagle Pass, and Workman Mountain Tracts of the Ozark Plateau National Wildlife Refuge. Infraspecific taxa are not included in the table, because they were only recognized if necessary to determine a species's rarity on the Oklahoma Natural Heritage Inventory's 2006 *Working List of Rare Oklahoma Plants.*

			Species		
	Families	Genera	Native	Introduced	Total
Pteridophyta	5	8	11	0	11
Coniferophyta	2	2	2	0	2
Magnoliophyta					
Magnoliopsida	72	222	316	27	343
Liliopsida	9	53	77	9	86
Total Taxa	88	285	406	36	442

In the Sally Bull Hollow Tract, 127 species in 104 genera and 52 families were encountered. In the 2001 and 2002 growing seasons, Hayes collected 219 species in 145 genera and 62 families in the tract (Hayes, 2003). She collected 59 species that were not encountered in this study. Conversely, I encountered 76 species that she did not. Thus at the present time, the vascular flora of Sally Bull Hollow comprises 295 species in 181 genera and 73 families.

In the Eagle Pass Tract, 255 species in 189 genera and 69 families were encountered, whereas in the Workman Mountain Tract had 287 species in 197 genera and 83 families.

In general, differences in distribution of species were related to habitat type and not correlated with the three tracts. Sally Bull Hollow exhibited wetter soils because of the proximity to major spring fed watersheds, extensive level bottomland areas and smaller areas of upland prairie remnants. There was also a greater diversity of spring wildflowers e.g., *Dicentra, Lobelia, Erythronium, Camassia*, and *Sanguinaria* in Sally Bull Hollow when compared with the other two tracts. In addition, Sally Bull Hollow was observed to exhibit more understory vegetation than did Eagle Pass or Workman Mountain. These differences may have also been related to the general orientation of the hollows in terms of incidence angle.

Endangered, Threatened, and Rare Species

Plant Species designated threatened or endangered by The Endangered Species Program of the USFWS (2001) were not encountered. *Platanthera leucophaea*, eastern prairie fringed orchid, and *P. praeclara*, western prairie fringed orchid, are listed as threatened in Oklahoma. Neither was expected to be present because of the lack of suitable prairie habitat. However, 4 of the 11 species designated rare in Adair County by the ONHI (2006) were discovered (Table 2). GPS coordinates for these four species were recorded and given directly to Steve Hensley, refuge manager of OPNWR. Additional populations of *Carex gracilescens* initially collected by Hayes (2003) were not

encountered in this survey. Prior to Hayes's work, this species had been reported to occur in Oklahoma, but was not documented in state herbaria.

Table 2.2 Taxa encountered in this study that are designated rare in Adair County by the Oklahoma Natural Heritage Inventory (2006). NHI Global and state natural heritage rankings are given in parentheses.

Taxa	NHI Ranking
Castanea pumila var. *ozarkensis*	(G5 T3 S2)
Corallorhiza odontorhiza	(G5 S1)
Elymus hystrix	(G5 S2 S3)
Monotropa uniflora	(G5 S1)

New Records for Adair County

As illustrated in Table 3, three ferns, 54 dicots, and 28 monocots discovered in the refuge constitute new records for Adair County (Hoagland et al., 2004). Of the 85 species, 7 are designated rare in parts of the state by the OHNI (Hoagland et al., 2006).

Table 2.3 Eighty-five taxa encountered in this study that constitute new country records for Adair County. If taxa are designated rare in parts of Oklahoma, global and state natural heritage rankings by the Oklahoma Natural Heritage Inventory (2006) are given in parentheses.

Agalinis tenuifolia (G5 S2 S3)	*Digitaria violascens*	*Prunus americana*
Agrostis hyemalis	*Diodia teres*	*Quercus falcata*
Agrostis perennans	*Eragrostis intermedia*	*Quercus prinoides*
Aira elegans	*Eragrostis spectabilis*	*Ranunculus sardous*
Ambrosia trifida. var. trifida f. integrifolia	*Erythronium americanum*	*Rhynchospora glomerata*
Amphiachyris dracunculoides	*Euphorbia spathulata*	*Rosa woodsii* (G5 S1)
Andropogon ternarius	*Festuca obtusa*	*Rubus aboriginum*
Anthriscus caucalis	*Galium pilosum*	*Rumex crispus*
Arabis missouriensis	*Geum canadense*	*Sanicula canadensis*
Aristida purpurea	*Glycyrrhiza lepidota*	*Saponaria officinalis*
Asplenium rhizophyllum	*Grindelia papposa*	*Saxifraga virginiensis*
Astragalus canadensis	*Houstonia ouachitana* (G3 S1)	*Scleria oligantha*
Astragalus racemosus	*Ipomoea coccinea*	*Setaria gracilis*
Botrychium biternatum	*Leptoloma cognatum*	*Setaria pumila*
Callicarpa americana	*Lespedeza frutescens*	*Smilax herbacea*
Carex albicans	*Lithospermum multiflorum*	*Solanum elaeagnifolium*
Carex cherokeensis	*Microstegium vimineum*	*Solidago canadensis*
Carex digitalis	*Mikania scandens*	*Solidago missouriensis*
Carex grisea	*Narcissus tazetta*	*Taenidia integerrima*
Carex meadii	*Nasturtium officinale*	*Trepocarpus aethusae*
Centaurea americana	*Oenothera macrocarpa*	*Trifolium hybridum*
Clematis virginiana (G5 S1 S2)	*Oligoneuron rigidum var. rigidum*	*Verbena bonariensis*
Coreopsis tinctoria	*Oxalis dillenii*	*Viola lanceolata*
Cyperus lupulinus	*Packera glabella*	*Viola sagittata*
Desmodium pauciflorum (G5 S1)	*Plantago patagonica*	*Viola triloba*
Dichanthelium ravenelii	*Plantago virginica*	*Vitis mustangensis* (G4 S2 S3)
Desmodium canescens	*Pleopeltis polypodioides*	*Vulpia octoflora*
Dicentra cucullaria (G5 S1 S3)	*Pluchea odorata*	
Dichanthelium acuminatum	*Poa compressa*	

Introduced Species

Of the 442 species encountered in this study, 406 or 92% were native. Introduced species that have naturalized and become abundant, according to the criteria of Rejmanek and Richardson (1996), include: *Lespedeza cuneata, Melilotus officiniale*, *Microstegium vimineum, Daucus carota, Perilla frutescens, Trifolium* spp., *Nasturtium officinale*, and *Albizia julibrissin*; although these taxa remain confined to conspicuously disturbed soils of the banks and gravel bars of the streams and roadsides. Other introduced species such as *Rosa multiflora, Dactylis glomerata, Potentilla recta,* and *Ranunculus sardous* were encountered throughout the tracts as scattered plants or small populations and typically not in the highly disturbed habitats occupied by the other introduced species. *Narcissus tazetta* was found only in one location, an abandoned home site, and is considered adventive.

Comparison to Previous Studies

Because of the paucity of information about the flora and vegetation of the Oklahoma Ozarks (Hoagland, 2000), the work reported here can be compared to only two studies. Hayes reported (2003) 219 species in 145 genera and 62 families to be present in the Sally Bull Hollow Tract. Her percentage of native species (91.3%) was essentially the same as that (92%) reported in this study. Wallis (1959) in his study of the entire Oklahoma Ozarks collected 328 species in Adair County, but did not collect within the present boundaries of the refuge.

The total vascular flora of Oklahoma comprises 2,540 species in 868 genera and 173 families. (Tyrl et al., 2007). Fourteen percent of these are non-native and 19% are

listed as S1, S2, or S3 by the ONHI (2006). The three tracts of the OPNWR inventoried in this study have 17% of the total species known to occur in Oklahoma, 10% of the introduced species, and 4.7% of the rare species.

Plant communities and habitats

Based on field reconnaissance and the classification of Hoagland (2000), 14 types of habitats occur in the three tracts of the OPNWR: (1) mesic slopes; (2) disturbed areas; (3) moist soils; (4) seeps; (5) cobble bars; (6) gravelly streams; (7) marshes and/or ponds; (8) uplands; (9) ravines; (10) lowlands; (11) woodlands; (12) riparian corridors; (13) xeric slopes; and (14) shallow rocky soils. The vegetation of the region is oak-hickory deciduous forest (Vankat 1992). Using the classification of Hoagland (2000), 15 associations and one alliance occur in the three tracts. To facilitate use by refuge personnel in the future, the 12 forest associations were combined into two more inclusive categories — xeric forest and mesic forest. Features of these two cateogries and those of five other vegetation types described by Hoagland (2000) are summarized in the following paragraphs.

1. Xeric Forests [XF] — this category encompasses plants of 4 Forest Associations: (1) *Quercus stellata-Quercus marilandica-Carya texana-Vaccinium arboreum,* (2) *Quercus stellata-Quercus marilandica-Carya texana,* (3) *Quercus stellata-Quercus shumardii-Carya cordiformis,* and (4) *Quercus stellata-Ulmus alata*. Xeric forests predominate on south-facing

and exposed slopes, and intergrade with adjacent woodlands and prairies. Typical understory species include: *Andropogon gerardii, Carex albicans, Danthonia spicata, Helianthus hirsutus, Rhus* spp., *Schizachyrium scoparium, Sporobolus asper, Symphoricarpos orbiculatus, Tephrosia virginiana,* and *Vaccinium arboreum.*

2. Mesic Forests [MF] — this category incorporates plants of 8 Forest Associations: (1) *Acer saccharum-Quercus alba-Carya alba,*(2) *Acer saccharum-Quercus rubra-Carya cordiformis,* (3) *Quercus alba-Carya alba-Tilia Americana,* (4) *Quercus falcata-Carya alba,* (5) *Quercus muehlenbergii-Acer saccharum,* (6) *Quercus muehlenbergii-Quercus shumardii,* (7) *Quercus rubra-Quercus shumardii,* and (8) *Fraxinus pennsylvanica-Ulmus americana*. Mesic forests predominate on north-facing slopes, protected slopes, and in bottomland areas. Associated species include: *Adiantum pedatum, Geranium maculatum, Hypericum hypericoides, Juglans nigra, Monarda* spp*., Myosotis verna, Nyssa sylvatica, Ostrya virginiana, Pedicularis canadensis, Sassafras albidum, Silene virginica,* and *Woodsia obtusa*.
3. *Acer saccharinum-Acer negundo* Forest Association [ASAN] – this association dominates stream margins and the slopes immediately adjacent to them. Associated species include: *Betula nigra, Castanea pumila* var. *ozarkensis, Lindera benzoin, Melica nitens, Polygonum* spp., *Quercus rubra, Toxicodendron radicans,* and *Vitis mustangensis.*

4. *Betula nigra-Platanus occidentalis* Forest Association [BNPO] — this association co-dominates with the ASAN association on cobble bars and in moist soils associated with seeps and streams. Typical species include: *Acer negundo, Chasmanthium latifolium, Parthenocissus quinquefolia, Phytolacca americana, Tridens flavus,* and *Hamamelis vernalis.*
5. *Quercus stellata-Quercus marilandica-Schizachyrium scoparium* Woodland Association [QSQM] — upland areas on ridge tops are often covered with this association. It characteristically has a more open canopy than the surrounding forests. The trees are scrubby in some cases as, depending on how exposed they are to the elements. Associated species include: *Andropogon gerardii, Antennaria parlinii, Baptisia bracteata, Carya texana, Crataegus crus-galli, Cornus drummondii, Juniperus virginiana, Prunus mexicana, Viburnum rufidulum, Rhus glabra, Schizachyrium scoparium,* and *Symphoricarpos orbiculatus.*
6. *Nasturtium officinale* Herbaceous Alliance [NOHA] — predominately in gravely streams and cobble bars, or free floating in streams. Associated species include: *Carex* spp., *Eleocharis* spp., *Juncus* spp., *and Scirpus* spp.
7. Disturbed areas [DIST] — this association was located along roadsides and ATV paths that cut through the refuge, or in areas of intense human alteration such as formerly logged areas or refuse dump sites. Common plants encountered were: *Verbascum thapsus, Achillea millefolium, Coreopsis tinctoria, Hordeum pusillum, Microstegium vimineum, Salix*

caroliniana, Rhus copallinum, Lespedeza cuneata, Trifolium spp., *Melilotus officinale*, and *Conyza canadensis.*

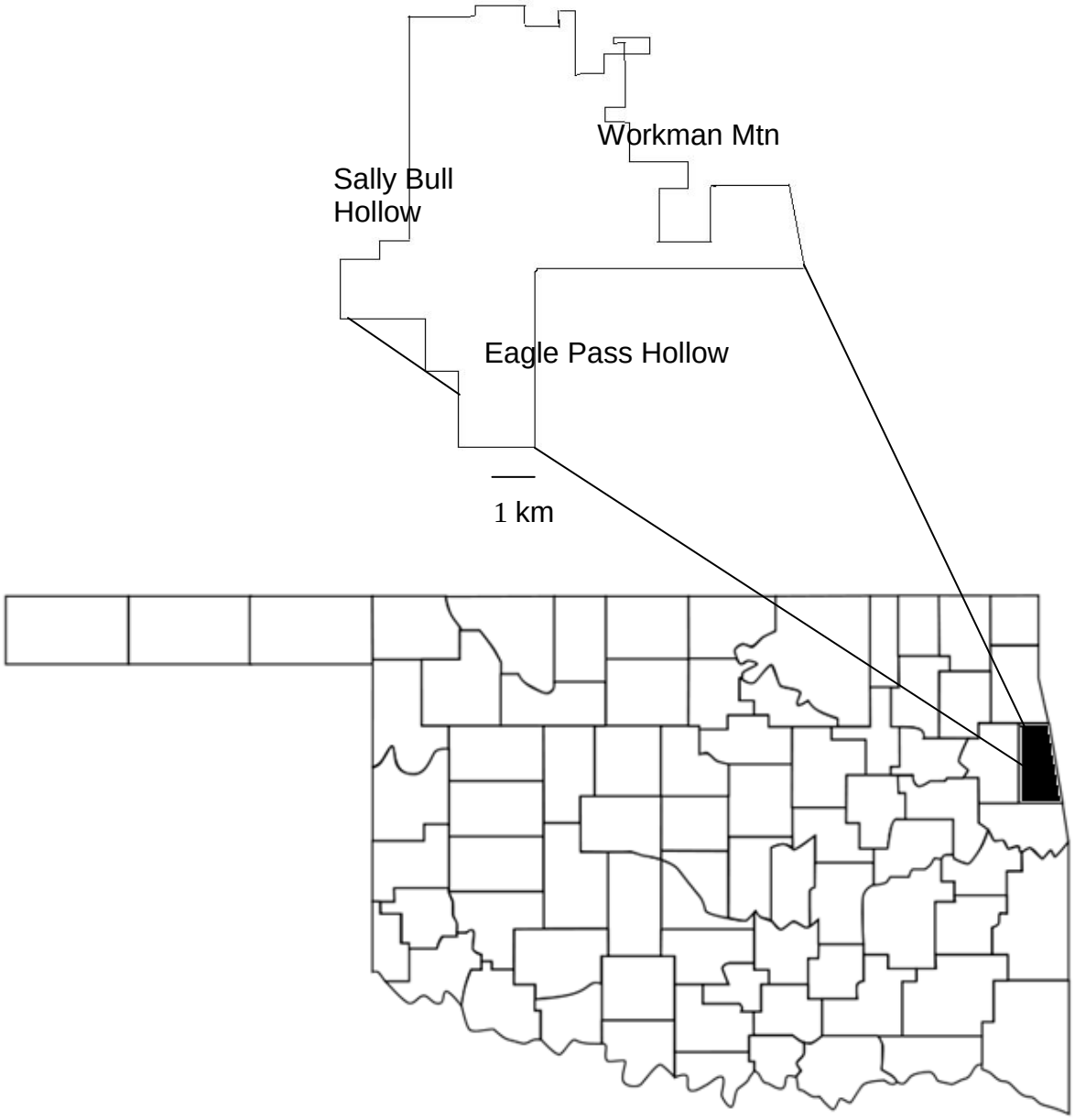

Figure 2.1 The Sally Bull Hollow, Eagle Pass, and Workman Mtn. tracts of the Ozark Plateau National Wildlife Refuge, 7.24 km southeast of the town of Stillwell, Adair County, OK.

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CHAPTER 3

A TAXONOMIC TREATMENT OF THE SPECIES OF *ERAGROSTIS* IN OKLAHOMA

ABSTRACT

Preparation of a taxonomic treatment of the genus *Eragrostis* (Poaceae) for the *Flora of Oklahoma* revealed that 14 native and 6 introduced species of the genus are present in the state. Eighty vegetative, inflorescence, and spikelet features of each species were measured or scored. The range of variation for each character was determined and recorded. Descriptions of each species were written. Nomenclatural, taxonomic, and ecological notes were added as appropriate to complement the morphological descriptions. A dichotomous key to the 20 species was prepared.

INTRODUCTION

The genus *Eragrostis*, commonly known as lovegrass and the type genus for the tribe Eragrostideae, was described by Nathaniel Wolf in 1776. Older agrostological references such as Hitchcock & Chase (1950) cited Palisot de Beauvois as the author, but his 1812 name lacks priority. Although Wolf gave no explanation for the origin of

the name in his description, Clifford (1996) provided three possible derivations for *Eragrostis*: (1) that it comes from the Greek word “eros” meaning “love” and “agrostis,” the Greek name for an indeterminate herb; (2) that it comes from the Greek roots “*er”* meaning “early” and “*agrostis”* meaning “wild” or “grass” and thus perhaps reflecting that some species of the genus are early invaders of arable land; or (3) that it comes from combining the Greek “eri,” a prefix meaning “very” or “much” with the genus name *Agrostis* to mean “many-flowered *Agrostis*.”

Fourteen native and six introduced species of *Eragrostis* are recognized in this treatment as present in Oklahoma. In North America, 25 native and 24 introduced species occur (Peterson, 2003). Worldwide, the genus comprises approximately 350 species (Clayton and Renvoize, 1986; Watson and Dallwitz, 1992). The genus is cosmopolitan in distribution, although more characteristic of tropical and subtropical regions. Plants tend to grow in disturbed, poor soils and are almost exclusively C4 photosynthetic (Clayton and Renvoize, 1986; Van den Borre and Watson, 1994; Ellis, 1984). Some species are also known to be important ground cover on oceanic islands (Rauzon, 2001), and others have economic potential as hyper accumulators of heavy metals (Prasad, 2004). *Eragrostis curvula,* weeping lovegrass*,* is cultivated for erosion control and as a pasture species in Oklahoma (Tyrl et al., 2008). *Eragrostis tef* is grown to make *injera*, a staple food in Ethiopia. In other parts of Africa, a few species are used as famine food. The caryopses are small and ideal for sowing by nomadic tribes given that several thousands make up a handful (NAS, 1996). Other species are grown for their ornamental value, soil stabilization abilities, and for their grain (Skerman et al., 1990). Caryopses of the genus are used by wildlife to a moderate degree, and some

species provide cover for nesting birds and small mammals (Hatch et al., 1999).

Classification of Oklahoma lovegrasses begins with H.I. Featherly's 1946 treatment, wherein he recognized 21 species. U.T. Waterfall in his 1969 *Keys to the Flora of Oklahoma* listed 22 taxa, and his treatment represented the last formal treatment of *Eragrostis* in the state. Unfortunately, as the title implies, his work lacked the morphological descriptions of the species needed to confirm identifications made through use of the keys. In addition, checklists such as that of Taylor and Taylor (1994) and the treatment of the genus by Peterson in the *Flora of North America* (2003) have differed in the number of taxa cited as present in Oklahoma (Table 1). Because of these differences in opinion as to the number of species present in the state and because of the changes in classification and nomenclature that have occurred in the genus, a modern treatment of the genus is needed for inclusion in the *Flora of Oklahoma*, a comprehensive taxonomic manual being written by the non-profit Flora of Oklahoma Corporation that was established in 1983 (Tyrl et al., 2008). The treatment offered here is one such contribution. In writing this treatment, objectives were two: (1) to determine which species of *Eragrostis* occur in Oklahoma, and (2) to write a comprehensive treatment comprising keys, descriptions, and nomenclatural notes for the genus and species using the format established by the *Flora of Oklahoma* Editorial Committee.

Table 3.1 Previous treatments of *Eragrostis* in Oklahoma and number of taxa included. Although there is considerable overlap, some uncertainty remained as to which taxa could actually be found in Oklahoma.

Treatment year & Author(s)				
Taxa included in treatment	Featherly 1946	Waterfall 1969	Taylor & Taylor 1994	Peterson 2003
E. barrelieri	●	●	●	●
E. beyrichii	●			
E. capillaris	●	●	●	●
E. chloromelas	●			
E. cilianensis	●	●	●	●
E. curtipedicellata	●	●	●	●
E. curvula	●	●	●	●
E. diffusa	●			
E. elliottii				●
E. frankii		●	●	●
E. glomerata		●	●	
E. hirsuta	●	●	●	●
E. hypnoides	●	●	●	●
E. intermedia	●	●	●	●
E. japonica				●
E. lehmanniana	●		●	
E. lugens	●			●
E. minor				●
E. oxylepis var. *beyrichii*		●	●	
E. oxylepis var. *oxylepis*		●		
E. pectinacea	●	●	●	●
E. pilifera	●			
E. pilosa	●	●	●	●
E. poaeoides		●		
E. refracta				●
E. reptans	●	●	●	●
E. secundiflora	●		●	●
E. secundiflora ssp. *oxylepis*			●	
E. secundiflora spp. *secundiflora*			●	
E. sessilispica	●	●	●	●
E. spectabilis	●	●	●	●
E. spectabilis var. *sparsihirsuta*		●	●	
E. trichodes	●	●	●	●
E. trichodes var. *pilifera*		●	●	
E. trichodes var. *trichodes*		●	●	
Total number of taxa :	21	22	24	21

PREPARATION OF THE TREATMENT

Preparation of this treatment of *Eragrostis* was a four-part process involving: (1) a review of the taxonomic literature for the genus; (2) an examination of herbarium specimens; (3) the development of a character list for the genus; and (4) the writing of keys and species descriptions. Aspects of each part are summarized in the following paragraphs.

Historical floristic treatments of *Eragrostis* in Oklahoma and elsewhere were reviewed to gain an understanding of what species were considered to be present in the state. Principal floras, manuals, and monographs examined included: Featherly (1946), Harvey (1948), Hitchcock (1950), Fernald (1950), Waterfall (1969), Correll and Johnston (1970), Gould (1975), Clayton and Renvoize (1986), Great Plains Flora Association (1986), Watson and Dallwitz (19 92), Taylor and Taylor (1994), Diggs, Lipscomb and O'Kennon (1999), and Peterson (2003). Journal articles reviewing specific classificatory or nomenclatural aspects of the genus, e.g., Koch (1974), also were reviewed.

As the literature was reviewed, herbarium specimens of the genus in the Oklahoma State University Herbarium (OKLA) and the Robert Bebb Herbarium (OKL) at the University of Oklahoma were identified and a list of the taxa present in Oklahoma was compiled (Table 2). This list served as the basis for subsequent examination of the specimens and development of the descriptions. A total of 1,147 specimens were available from these herbaria. In some species, as many as 167 specimens were utilized; in other species, only as few 5 as collections were available for comparison. On average, there were 57 specimens per species. If specimens numbered fewer than 10

for a particular species, a comment was included regarding this in the nomenclatural notes following that species description.

In order to determine the range of morphological variation exhibited by each species in the state, 80 morphological characters were measured or scored (Table 3). These characters encompassed the vegetative, inflorescence, and spikelet features of each taxon. The range of variation for each character was determined and recorded. These character measurements and states were entered into Microsoft Excel ® spreadsheets to insure recording of the same data for all taxa and to facilitate comparisons during construction of the key to species. Information extracted from herbarium labels and the Oklahoma Vascular Plants Database (2008) was used to generate distributional and ecological information about each species. Nomenclatural, taxonomic, and ecological notes were added as appropriate to complement the morphological descriptions. Abbreviation of the author name or names following each taxon's scientific name is according to Brummitt and Powell (1992).

The key to the 20 species of *Eragrostis* present in Oklahoma was reviewed and edited by the Editorial Committee of *the Flora of Oklahoma* Project and incorporated into the 2007and subsequent versions of *Keys & Descriptions for the Vascular Plants of Oklahoma.* The species descriptions likewise will be edited by the Editorial Committee and subsequently incorporated into the *Flora of Oklahoma.*

Table 3.2 Species of *Eragrostis* occurring in Oklahoma based on a survey of the literature and an examination of herbarium specimens deposited in state herbaria.

E. barrelieri	*E. hypnoides*	*E. pilosa*
E. capillaris	*E. intermedia*	*E. reptans*
E. cilianensis	*E. japonica*	*E. secundiflora*
E. curvula	*E. lehmanniana*	*E. sessilispica*
E. curtipedicellata	*E. lugens*	*E. spectabilis*
E. frankii	*E. minor*	*E. trichodes*
E. hirsuta	*E. pectinacea*	

Table 3.3 Eighty morphological characters examined and scored in order to generate descriptions of species of *Eragrostis* in Oklahoma.

Plant	aromaticity		**Panicle**	position		
	longevity			habit		
	habit			shape		
	spikelet sexuality			width		
	adventitious root system	type		length		
		length	**Peduncle**	disarticulation		
		diameter	**Rachis**	shape		
		pubescence		length		
				pubescence		
Culm	height		**Primary Branch**	number		
	diameter			habit		
	habit			width		
Node	diameter			length		
	color			pubescence		
	texture		**Pedicel**	presence		
	pubescence			habit		
Internode	texture			width		
	anatomy			length		
	color			pubescence		
	pubescence		**Spikelet**	width		
Leaf	phyllotaxy			length		
Sheath	shape		**Floret**	number		
	length		**Glume**	position		
	color			length		
	texture			shape		
	pubescence			nerve number		
Ligules	pubescence			pubescence		
	length			apex shape		
	apex shape		**Lemma & Palea**	length		
Auricle	presence			shape		
Collar	distinction			nerve number		
	color			pubescence		
	pubescence			apex shape		
Blade	habit			disarticulation		
	shape		**Stamen**	number		
	width			anther length		
	length		**Caryopses**	shape		
	pubescence			length		
Spathe	presence			color		

TREATMENT

Eragrostis Wolf Lovegrass

Plants strongly aromatic or not aromatic; annuals or perennials; typically cespitose or tussock forming or spreading by rhizomes or stolons; bearing perfect spikelets or dioecious. **Rhizomes** knotty; typically producing aerial culms along entire length; obliquely ascending; less than 5 cm long; 3 mm or more in diameter; scale leaves present; glabrous. **Stolons** long or short; less than 3 mm in diameter; wiry; naked; glabrous. **Culms** 2-150 cm tall; erect or ascending or geniculate or decumbent; 0.3-2.5 mm in diameter; unbranched, or branched at lower or upper nodes. **Nodes** equal in diameter to internodes or constricted; stramineous or brown or purplish green or reddish green; glaucous or not glaucous; glandular or eglandular; not coated with a secretion or viscid; glabrous or pilose, hairs dense. **Internodes** with or without a yellowish glandular band below each node; solid or hollow; green or purplish green or reddish green or stramineous; not coated with a secretion or viscid; glabrous or pilose, hairs dense or sparse. **Leaves** primarily basal or both basal and cauline or primarily cauline or strictly cauline. **Sheaths** with or without crateriform glands on midnerves; keeled or rounded on back; longer or shorter than internodes; green or purplish green or reddish green; glandular or eglandular; not coated with a secretion or viscid; glabrous or pilose or hirsute, hairs not arising from swollen bases or arising from pustules, dense or sparse, typically restricted to apex or restricted to distal half or distributed from bases to apices; margins free,

membranous or occasionally foliaceous, entire or scaberulous or ciliate or pustulate-ciliate; basal sheaths persistent when dead, resembling living sheaths, soft. **Ligules** ciliate or membranous only in *E. japonica*; 0.1-0.9 mm long; apices truncate. **Auricles** absent. **Collars** conspicuous, or indistinct and not well differentiated from blades and sheaths; green or brown or reddish purple or yellow green; glabrous or pilose, hairs dense or sparse. **Blades** ascending or appressed or spreading or reflexed or curled; linear or lanceolate; firm or lax; flat or involute or folded; narrower or wider than sheaths, 1-8 mm wide; 1-45 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or scaberulous or pilose or hirsute; hairs not arising from swollen bases or arising from pustules, dense or sparse, restricted to proximal half or restricted to base or distributed from bases to apices; abaxial midribs conspicuous or not conspicuous; not different in color or stramineous; abaxial surfaces glabrous or scaberulous or pilose; hairs dense or sparse; apices acute or filiform or attenuate; margins foliaceous or entire or scaberulous. **Spathes** absent. **Panicles** terminal or axillary; open or loosely contracted or densely contracted or diffuse or spicate; rachises and pedicels visible or partially visible or not visisble; ovate or oblong or elliptic or lanceolate or ovoid or globose; erect or nodding or reclining; 2-40 cm wide; 2-100 cm long. **Peduncles** not disarticulating and persistent at maturity, or disarticulating and entire panicles breaking free from plants at maturity; 1-40 cm long; partially enclosed or not partially enclosed in sheaths at anthesis; glabrous or glabrate or scabrous; glandular or eglandular. **Rachises** curved or straight or slightly wavy or flexuous or recurved; 1-55 cm

long; glabrous or scabrous or pubescent; glands absent. **Primary branches** one to several per node; ascending or spreading or appressed or diverging; capillary or slender; 0.1-40 cm long; glabrous or glabrate or scabrous or pubescent or ciliolate; pulvini in axils absent or present. **Pedicels** absent or present; ascending or spreading or divergent or appressed; slender or capillary; 0.2-30 cm long; glabrous or scaberulous or scabrous or ciliolate or pubescent or viscid; glandular or eglandular. **Spikelets** 0.5-4.7 mm wide; 1.5-18 mm long. **Florets** 2-60; **Lower Glumes** 0.4-6 mm long; ovate or lanceolate; nerves inconspicuous to 3-nerved; midnerves glabrous or pubescent or scabrous; apices acute or obtuse or acuminate. **Upper Glumes** 0.6-7 mm long; ovate or lanceolate; nerves inconspicuous to 3-nerved; midnerves glabrous or scabrous or scaberulous; apices acute or acuminate. **Lemmas** 0.9-6 mm long; ovate or lanceolate; nerves 1-3; midnerves glabrous or glabrate or scaberulous or scabrous; apices acute or obtuse or acuminate; absent or present at maturity. **Paleas** 0.5-4.6 mm long; ovate or lanceolate; nerves inconspicuous to 2-nerved; midnerves scabrous or glandular or glabrous or pubescent; margins glabrous or ciliolate; apices acute or rounded or obtuse; present or absent at spikelet maturity. **Stamens** 2 or 3; anthers 0.1-2.2 mm long. **Caryopses** of various shapes; 0.3-1.6 mm long; various shades of brown or red or gold.

Eragrostis, commonly known as the lovegrass genus, comprises approximately 350 species worldwide and grows in tropical to subtropical regions. The origin of the name is not known because Nathaniel Wolf (1776) made no reference

concerning its etymological roots (Peterson, 2003). One hundred eleven species are in the Western Hemisphere and in North America, there are 25 native species and 24 introduced species (Peterson, 2005). In Oklahoma, 20 species are documented, and of these, six are introduced.

Most species of *Eragrostis* occupy open areas that are often disturbed or have poor soil quality (Peterson, 2003). Various small mammals and birds are known to browse the herbage and eat the caryopses (Hatch et al., 1999). One species, *Eragrostis tef*, is an important food crop food in parts of Africa (Ingram, 2003). *Eragrostis cilianensis*, an introduced species found in Oklahoma, is a famine food in Lesotho (Smith, 1966). A few species are used in ornamental plantings, and others have been widely used in combating soil erosion around the globe (Tyrl et al., 2008).

Eragrostis N.M. von Wolf Lovegrass

1. Plants stoloniferous; mat-forming. Erect culms 2-10 cm tall.
   2. Panicles globose or subglobose. Lemmas sparsely villous. Plants dioecious. Stamens 3; anthers 1.5-2.2 mm long. ..... ***E. reptans*** (=*Neeragrostis reptans*)
   2. Panicles ellipsoidal to fusiform or cylindrical. Lemmas glabrous. Plants bearing perfect flowers. Stamens 2; anthers 0.2-0.3 mm long. ..... ***E. hypnoides***
1. Plants cespitose; not mat-forming. Erect culms 10-150 cm tall.
   3. Ligules membranous. ..... ***E. japonica*** (including *E. glomerata*)
   3. Ligules ciliate or ciliate-membranous.
      4. Crateriform glands present, on pedicels and/or sheaths and/or blade margins and/or lemma midnerves.
         5. Lemmas 1.4-1.8 mm long. Stamens 2; anthers at anthesis reddish brown. Spikelets 1.1-2.2 mm wide. Pedicels typically with glandular band above middle. ..... ***E. minor*** (=*E. poaeoides*)
         5. Lemmas 2-2.8 mm long. Stamens 3; anthers at anthesis yellow. Spikelets 2.5-4 mm wide. Pedicels without glandular band. ..... ***E. cilianensis***
      4. Crateriform glands absent.
         6. Plants annuals; remnants of previous year's culms absent.
            7. Majority of spikelets with 2-6 florets. Caryopses ovoid to rectangular-prismatic; adaxial surfaces with 1 longitudinal groove.
               8. Sheath margins glabrous. Pedicels 1.5-5 mm long. Panicles narrowly elliptic; less than 1/2 height of plants. Anthers at anthesis purplish. Internodes typically with glandular pits below nodes. ..... ***E. frankii***
               8. Sheath margins pilose. Pedicels 5-25 mm long. Panicles ovate to broadly elliptic; 1/2-3/4 height of plants. Anthers at anthesis reddish brown. Internodes without glandular pits below nodes. ..... ***E. capillaris***
            7. Majority of spikelets with 6-35 florets. Caryopses ellipsoid or pyriform, or obovate to prismatic; adaxial surfaces smooth, not longitudinally grooved.
               9. Lower glumes as long as upper glumes.
                  10. Spikelets 2.5-4 mm wide. ..... ***E. cilianensis***
                  10. Spikelets 1-2.2 mm wide. ..... ***E. barrelieri***
               9. Lower glumes 1/2-3/4 length of upper glumes.
                  11. Panicle branches whorled at lowest 2 nodes of rachises. Lower glumes 1/4-1/3 length of lowest lemma. Paleas dropping from rachises with lemmas or shortly after. ..... ***E. pilosa***
                  11. Panicle branches alternate or opposite at lowest 2 nodes of rachises. Lower glumes 1/2-3/4 length of lowest lemma. Paleas persistent on rachises after lemmas have dropped.
                     12. Pedicels typically with glandular band above middle. Stamens 2; anthers reddish brown at anthesis. ..... ***E. minor*** (=*E. poaeoides*)
                     12. Pedicels without glandular band. Stamens 3; anthers purplish at anthesis. ..... ***E. pectinacea***
         6. Plants perennials; remnants of previous year's culms present. ..... **couplet 13**

13. Lemma backs rounded; nerves inconspicuous, light.
   14. Sheaths pustulate-pilose or pustulate-hirsute. ..... ***E. hirsuta***
   14. Sheaths glabrous or glabrate or pilose in tufts at apices, hairs not pustulate based.
      15. Blades 3-11 mm wide. Sheaths longer than internodes. ..... ***E. hirsuta***

15. Blades 1-3.5 mm wide. Sheaths shorter than internodes.
    16. Spikelets 1-1.8 mm wide. Lower glumes 1-1.7 mm long. Sheath margins sparsely pilose. Longitudinal groove of adaxial surfaces of caryopses conspicuous. ..... ***E. intermedia***
    16. Spikelets 0.5-1 mm wide. Lower glumes 0.5-1 mm long. Sheath margins glabrous. Longitudinal groove of adaxial surfaces of caryopses absent or inconspicuous. ..... ***E. lugens***

13. Lemma backs keeled; nerves conspicuous, dark.
    17. Plants rhizomatous; rhizomes short, knotty.
        18. Culms and sheaths and rachises and panicle branches viscid. Pedicels 0.2-1.2 mm long; appressed against branches. Peduncles not disarticulating; entire panicles not separating from plants. Caryopses terete; adaxial surfaces not longitudinally grooved. ..... ***E. curtipedicellata***
        18. Culms and sheaths and rachises and panicle branches not viscid. Pedicels 1.5-17 mm long; spreading. Peduncles disarticulating; entire panicles separating from plants. Caryopses flattened; adaxial surfaces longitudinally 1-grooved. ..... ***E. spectabilis***
    17. Plants not rhizomatous.
        19. Spikelets diverging from branches. Pedicels present; flexuous; capillary; longest 5-22 mm long. ..... ***E. trichodes***
        19. Spikelets appressed against branches. Pedicels absent, or if present, straight; not capillary; longest no more than 5 mm long.
            20. Spikelets widely spaced, not overlapping. Primary branches stout, typically not bearing secondary branches. ..... ***E. sessilispica***
            20. Spikelets closely spaced, overlapping. Primary branches slender, bearing secondary branches.
                21. Plants forming large tufts with leaves primarily basal. Blades conspicuously arching; linear-filiform; 20-45 cm long. Ligules 0.5-0.8 mm long. ..... ***E. curvula***
                21. Plants forming small tufts with leaves both basal and cauline. Blades straight or slightly curved, but not arching; linear-lanceolate; 5-15 cm long. Ligules 0.2-0.5 mm long.
                    22. Spikelets ovate to linear-elliptic; 2.4-5 mm wide; reddish purple, or stramineous with reddish purple margins. Florets 10-45. Lemmas 2-6 mm long. Leaf blades flat. ..... ***E. secundiflora*** (including *E. oxylepis*, *E. beyrichii*)
                    22. Spikelets linear-lanceolate; 0.8-1.2 mm wide; lead green, or stramineous without reddish purple margins. Florets 4-12. Lemmas 1.5-1.7 mm long. Leaf blades involute. ..... ***E. lehmanniana***

***Eragrostis barrelieri* Daveau Mediterranean Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 20-60 cm tall; decumbent or geniculate or rarely erect; 0.5-1 mm in diameter; unbranched or branched at lower nodes. **Nodes** equal in diameter to internodes or slightly constricted; dark brown or purplish green; not glaucous; glandular; glabrous. **Internodes** typically with a conspicuous yellowish glandular band below each node; solid or hollow; purplish green or reddish green or stramineous; glabrous. **Leaves** primarily cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; shorter than internodes; green or purplish or reddish green; pilose, hairs not arising from swollen bases, dense, 2-5 mm long, restricted to apices typically forming a tuft; margins free, membranous or foliaceous, sparsely ciliate. **Ligules** ciliate; 0.3-0.7 mm long; apices truncate. **Collars** conspicuous or indistinct and not well differentiated from blades and sheaths; yellow-green; glabrous or pilose at margins, hairs dense or sparse. **Blades** ascending; linear or linear-lanceolate; flat or involute upon drying; wider or narrower than sheaths; 2-4 mm wide; 3-9 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or pilose, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, pale green; abaxial surfaces glabrous; apices acute or rarely attenuate; margins foliaceous; entire or scaberulous; crateriform glands absent. **Panicles** both terminal and axillary; loosely contracted, rachises and branches clearly visible; ovate; erect; 2-10 cm wide; 4-16 cm long. **Peduncles** not disarticulating and panicles not breaking free at maturity; 1-5 cm long; partially enclosed in sheaths

at anthesis; glabrous; glands absent. **Rachises** slightly wavy; 2-10 cm long; glabrous; glands absent. **Primary branches** one or rarely 2 per node; ascending; capillary; 2-30 cm long; scabrous along margins; pulvini in axils present, glabrous, golden yellow. **Pedicels** spreading; capillary; 1-4 m long; scabrous; glands absent. **Spikelets** 1-2 mm wide; 4-18 mm long. **Florets** 4-23; **Lower Glumes** 0.7-1.3 mm long; ovate; nerves 1; midnerves glabrous; apices acute. **Upper Glumes** 1-1.9 mm long; ovate; nerves 1; midnerves glabrous; apices acute. **Lemmas** 1.4-2.5 mm long; ovate; nerves 3; midnerves scabrous; apices acute to obtuse; dropping from rachillas at maturity. **Paleas** 1.3-1.7 mm long; lanceolate; nerves 2; midnerves scabrous; apices rounded; dropping from rachillas at maturity. **Stamens** 3; anthers 0.2-0.3 mm long. **Caryopses** oblong; 0.7-1 mm long; rusty brown to tan.

Eragrostis barrelieri is native to the Mediterranean region and occupies disturbed, sandy sites, primarily in the southwestern quarter of the United States. It is noted to occur frequently along railroad tracks (Peterson, 2005). In Oklahoma, it occurs throughout the state, with collections more heavily concentrated in the western half (Hoagland et al., 2004).

***Eragrostis capillaris* (L.) Nees Lacegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 5-45 cm tall; erect or rarely geniculate; 0.7-1.3 mm in diameter, unbranched or rarely branched at lower nodes. **Nodes** equal in diameter to internodes or occasionally slightly constricted; dark brown or stramineous; glandular; glabrous. **Internodes** solid or hollow; stramineous or occasionally reddish green; glabrous. **Leaves** primarily cauline. **Sheaths** keeled; shorter than internodes; green or purplish or reddish green; pilose, hairs occasionally arising from pustules, dense or sparse, 3-5 mm long, distributed from bases to apices; margins free, foliaceous or occasionally membranous, entire or ciliate. **Ligules** ciliate; 0.2 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths; green or brown; pilose at margins, hairs dense. **Blades** ascending; linear; typically flat or sometimes involute; wider or narrower than sheaths; 2-6 mm wide; 10-30 cm long; relatively uniform in length along culms; adaxial surfaces pilose, hairs arising from pustules, sparse or dense, distributed from base to apices or restricted to proximal half; abaxial midribs conspicuous; pale green or stramineous; abaxial surfaces glabrous; apices attenuate or filiform; margins foliaceous; entire or scaberulous. **Panicles** only terminal; open; elliptic; erect; occasionally reddish purple; 8-23 cm wide; 15-40 cm long. **Peduncles** not disarticulating and panicles breaking free at maturity; 1-5 cm long; partially enclosed in sheaths at anthesis; scabrous; glands absent. **Rachises** straight; 10-40 cm long; scabrous; glands absent. **Primary branches** 1-2 per node; spreading; capillary; 2-15 cm long; scabrous; pulvini in axils present, glabrous.

Pedicels ascending; capillary; 4-25 mm long, more than twice the length of spikelets; scabrous; glands absent. **Spikelets** 0.9-2 mm wide; 1.5-3.3 mm long. **Florets** (1)2-3(4). **Lower Glumes** 0.7-1.6 mm long; narrowly lanceolate; nerves 1; midnerves scabrous; apices acute. **Upper Glumes** 0.9-1.7 mm long; lanceolate; nerves 1; midnerves scabrous; apices acute. **Lemmas** 1.2-1.8 mm long; ovate; nerves 3, lateral ones faint; midnerves scaberulous; apices acute; dropping from rachillas at maturity. **Paleas** 1.2-1.6 mm long; ovate to lanceolate; nerves 1; midnerves scaberulous; apices acute; persistent on rachillas at maturity. **Stamens** 3; anthers 0.2-0.3 mm long; **Caryopses** lanceolate; 0.5-0.8 mm long, reddish-brown at the base becoming opaque towards the apex.

Eragrostis capillaris is native to Oklahoma and is found more frequently in the eastern half of Oklahoma(Hoagland et al., 2004). It grows in open, dry sandy soils of woodlands and riparian areas over much of the eastern United States (Featherly, 1946; Peterson 2003).

Eragrostis cilianenis **(All.) Vignolo ex Janch. Stinkgrass**

Plants strongly aromatic when fresh; annuals; cespitose; bearing perfect spikelets. **Culms** 10-35 cm tall, or 5 cm tall; geniculate or ascending or erect; 0.5-1.2 mm in diameter; unbranched or branched at lower nodes. **Nodes**

equal in diameter to internodes or slightly constricted; light or dark brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; solid; stramineous; glabrous. **Leaves** primarily cauline. **Sheaths** with glandular pits or sometimes crateriform glands on midnerves; slightly keeled; shorter than internodes; green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, 1-3 mm long, restricted to apices and typically forming a tuft; margins free, foliaceous, entire. **Ligules** ciliate; 0.3-0.9 mm long; apices truncate. **Collars** conspicuous or indistinct and not well differentiated from blades and sheaths; yellow-green; pilose at edges, hairs dense or sparse. **Blades** ascending; linear or linear-lanceolate; flat or involute upon drying; wider or narrower than sheaths; 3-6 mm wide; 3-15 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or rarely pilose, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, pale green; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire or with crateriform glands present especially near blade bases. **Panicles** only terminal; densely contracted, pedicels and rachises partially visible; oblong to ovate; erect; greenish to stramineous; 2-7 cm wide; 2-12 cm long. **Peduncles** not disarticulating, panicles persistent at maturity; 1-10 cm long; lower peduncles partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 4-15 cm long; glabrous; glands absent. **Primary branches** usually 1 but up to 4 per node; appressed to ascending; slender; 0.4-5 cm long; scabrous; glands absent; pulvini in axils present, glabrous or with tufts of white hairs. **Pedicels** divergent; slender;

0.2-3 mm long; scabrous. **Spikelets** 2-3.6 mm wide; 3-15 mm long. **Florets** 5-33. **Lower Glumes** 1.3-2.1 mm long; ovate; nerves 1or 3; midnerves scabrous with crateriform shaped glands on surface; apices acute. **Upper Glumes** 1.4-2.3 mm long; ovate; nerves 3; midnerves scabrous with crateriform shaped glands; apices acute. **Lemmas** 1.7-2.4 mm long; ovate; nerves 3; midnerves glandular; apices acute; dropping from rachillas at maturity. **Paleas** 1.2-2.1 mm long; ovate; nerves 2; margins ciliate; apices acute; dropping from rachillas at maturity. **Stamens** 3; anthers 0.2-0.4 mm long. **Caryopses** globose; 0.4-0.85 mm long, shiny and dark gold.

Eragrostis cilianensis is an introduced Mediterranean species that has naturalized in disturbed areas throughout Oklahoma and all of the continental United States, especially in poor soils (Hoagland et al., 2004; Peterson, 2003). Generally regarded as unpalatable to livestock, fresh plants have a distinct odor (Peterson, 2003; 2005; Tyrl, 2001).

***Eragrostis curvula* (Schrad.) Nees Weeping Lovegrass**

Plants not aromatic; perennials; strongly cespitose, forming large tufts; bearing perfect spikelets. **Culms** 75-150 cm tall; erect; 1.5-2.5 mm in diameter; branched at lower nodes or occasionally branched at upper nodes. **Nodes** slightly constricted; stramineous or brown; glandular; glabrous. **Internodes** solid;

green or purplish green or reddish green or stramineous; glabrous. **Leaves** primarily basal. **Sheaths** rounded on back or slightly keeled; longer than internodes or shorter than internodes; green or purplish or reddish green; pilose or occasionally glabrous, hairs not arising from swollen bases, sparse, 1-3 mm long, distributed from bases to apices or restricted to apices forming a tuft; margins free. **Ligules** ciliate; 0.5-0.8 mm long; apices truncate. **Collars** conspicuous or indistinct and not well differentiated from blades and sheaths; green or reddish purple; glabrous or pilose at edges, hairs dense. **Blades** conspicuously arching; linear; lax; involute; equal in width to or narrower than sheaths; 1.2-3 mm wide; 20-45 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or distally scaberulous and/ or pilose behind ligules, hairs not arising from swollen bases, dense; abaxial midribs not conspicuous, not different in color. abaxial surfaces glabrous or scaberulous; apices filiform; margins foliaceous, scaberulous. **Panicles** only terminal; loosely contracted, rachises and branches clearly visible; ovate to oblong; nodding; lead-green; 6-25 cm wide; 16-40 cm long. **Peduncles** not disarticulating, persistent at maturity; 10-35 cm long; not partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** curved; 12-35 cm long; glabrous; glands absent; **Primary branches** 1-3 per node; spreading; capillary; 3-14 cm long; glabrate to scaberulous; glands absent; pulvini in axils present, with a tuft of white hairs. **Pedicels** appressed; capillary; 0.5-5 mm long; scabrous; glands absent. **Spikelets** 1-2 mm wide; 3.5-8.5(10) mm long. **Florets** 3-10. **Lower Glumes** 1-2 mm long; lanceolate; nerves 1; midnerves glabrous; apices acute. **Upper**

Glumes 2-3 mm long; lanceolate; nerves 1; midnerves glabrous; apices acute. **Lemmas** 2-3 mm long; ovate; nerves 3; midnerves glabrous; apices acute; persistent or dropping from rachillas at maturity. **Paleas** 1.8-3 mm long; ovate; nerves 2, midnerves glabrous; apices acute; persistent or dropping from rachillas at maturity. **Stamens** 3; anthers 0.9-1.5 mm long. **Caryopses** ovate to elliptic; 1.2-1.6 mm long; golden pale but with a darker colored hilum area.

Eragrostis curvula was introduced from Africa as an ornamental and for soil stabilization, but has been found to provide highly nutritious forage for cattle when managed properly, especially in conjunction with natural range (McIlvain, 1976). Naturalized along woodland margins, roadsides and waste areas, it is most abundant in the western half of Oklahoma (Hoagland et al., 2004). It grows in sandy to loamy soils, and will not tolerate poor drainage (Miller, 1958; Tyrl et al., 2008). In the United States, *E. curvula* grows throughout the southern half of the country, with populations heavily concentrated in the southwest (Peterson, 2003).

***Eragrostis curtipedicellata* Buckley Gummy Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 40-75 cm tall; erect or geniculate; 1-1.5 mm in diameter; branched at lower nodes and occasionally branched at upper nodes. **Nodes** equal in diameter to internodes; stramineous or brown; glandular; viscid; glabrous.

Internodes hollow; stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** rounded on back; longer or shorter than internodes; green; frequently viscid; pilose, hairs sparse, 1-3 mm long, restricted to apices and forming a tuft; margins free, membranous, ciliate to sparsely pilose. **Ligules** ciliate; 0.1-0.2 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths; green; pilose at margins, hairs sparse. **Blades** ascending or spreading; linear; flat or involute; equal to or narrower than sheaths; 2-6 mm wide; 5-12 cm long; relatively uniform in length along culms, adaxial surfaces scaberulous or pilose behind ligule, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous; apices attenuate; margins foliaceous, scaberulous. **Panicles** only terminal; open; broadly ovate; erect; stramineous to reddish-purple; 8-30 cm wide; 15-40 cm long. **Peduncles** not disarticulating, persistent at maturity; 1-5 cm long; partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 7-25 cm long; scabrous; glands absent. **Primary branches** 1-3 per node; ascending; slender; 3-18 cm long; scabrous; pulvini in axils present with a tuft of white hairs. **Pedicels** appressed; capillary; 0.2-1.2 mm long; scabrous; glands absent. **Spikelets** 1-2 mm wide; 4-7.5 mm long. **Florets** 3-10. **Rachillas** disarticulating at maturity. **Lower Glumes**1-2 mm long; lanceolate; nerves 1; midnerves scabrous; apices acute; present at spikelet maturity. **Upper Glumes** 2-3 mm long; lanceolate; nerves 1; midnerves scabrous; apices acute; present at spikelet maturity. **Lemmas** 1.4-2 mm long; ovate to lanceolate; nerves 3; midnerves scabrous; apices acute; persistent or dropping from rachillas at

maturity. **Paleas** 1.2-2 mm long; lanceolate; nerves 2; margins ciliate; apices acute; persistent or dropping from rachillas at maturity. **Stamens** 3; 0.2-0.4 mm long. **Caryopses** oblong; 0.6-0.8 mm long; rust brown.

Eragrostis curtipedicellata is a native species that grows along roadsides, in pastures and at the woodland-prairie interface across Oklahoma (Featherly, 1946). In North America, the range extends from southern Colorado, Kansas and Missouri into northeastern Mexico (Peterson, 2003).

***Eragrostis frankii* C. A. Mey. ex Steud. Sandbar Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 5-30 cm tall; geniculate or ascending or rarely erect; 0.5-0.8 mm in diameter; typically branched or occasionally unbranched at lower nodes. **Nodes** equal in diameter to internodes or occasionally slightly constricted; dark brown or orangish; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; stramineous or occasionally reddish green; glabrous. **Leaves** primarily cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; keeled; shorter than internodes; green or purplish or reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, sparse, 2-3 mm long, restricted to apices and forming a tuft; margins free, foliaceous or occasionally membranous, entire. **Ligules** ciliate; 0.1-0.7 mm long; apices truncate. **Collars** typically conspicuous; brown; pilose at margins, hairs sparse.

Blades ascending; linear; typically flat or sometimes involute; wider or narrower than sheaths; 1-3 mm wide; 6-15 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or scaberulous; abaxial midribs conspicuous or not conspicuous, not different in color; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire or scaberulous. **Panicles** only terminal; open to diffuse; narrowly elliptic; erect; reddish green; 3-12 cm wide; 7-26 cm long**. Peduncles** not disarticulating, persistent at maturity; 1-7 cm long; partially enclosed in sheaths at anthesis; glabrate; glands absent. **Rachises** straight; 7-22 cm long; pubescent, hairs arachnoid; glands absent. **Primary Branches** 1-2 per node; spreading; capillary; 2-6 cm long; pubescent, hairs arachnoid; glands absent; pulvini in axils present with tufts of white hairs. **Pedicels** spreading; capillary; 1.5-5 mm long; pubescent, hairs arachnoid; glands absent. **Spikelets** 1-2.5 mm wide; 1.5-3.5 mm long. **Florets** 2-6. **Lower Glumes** 0.7-1.5 mm long; lanceolate; nerves 1; midnerves scabrous; surfaces pubescent, hairs arachnoid; apices acute. **Upper Glumes** 1-1.7 mm long; lanceolate; nerves 1; midnerves scabrous; surfaces pubescent, hairs arachnoid; apices acute. **Lemmas** 1-1.7 mm long; ovate; nerves 3, lateral ones inconspicuous; midnerves scabrous; apices acute; dropping from rachillas at maturity. **Paleas** 1-1.5 mm long; ovate; nerves 2; midnerves scaberulous; apices obtuse; persistent on rachillas at maturity. **Stamens** 2 or 3; anthers 0.2-0.3 mm long. **Caryopses** oblong to rectangular; 0.4-0.7 mm long; brown.

Eragrostis frankii is a native species that grows primarily in the eastern half of

Oklahoma in moist meadows and along stream banks (Hoagland et al., 2004). In North America, it is found throughout the eastern United States (Peterson, 2003).

***Eragrostis hirsuta* (Michx.) Nees Bigtop Lovegrass**

Plants not aromatic; perennials; strongly cespitose forming large tufts; bearing perfect spikelets. **Culms** 45-100 cm tall; erect; 1-1.2 mm in diameter; unbranched. **Nodes** slightly constricted; stramineous or brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; green or stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; longer than internodes; green or purplish or reddish green; not coated with a secretion; pilose or hirsute, hairs rarely arising from swollen bases, dense or sparse, 2-5 mm long, restricted to but conspicuous in distal half and also forming tuft at apices; margins free, membranous, entire. **Ligules** ciliate; 0.1-0.2 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths; green, yellow-green or reddish purple; pilose, hairs not arising from swollen bases or arising from pustules, dense. **Blades** ascending or curled; linear or linear-lanceolate; firm or lax; typically flat or involute; equal to or narrower than sheaths; 3-8 mm wide; 15-40 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or distally scaberulous or pilose behind ligules, hairs not arising from swollen bases, dense; abaxial midribs conspicuous, not different in color or

stramineous; abaxial surfaces glabrous or scaberulous; apices attenuate; margins foliaceous, scaberulous. **Panicles** only terminal; open; broadly ovate; erect; greenish to sometimes purplish; 15-40 cm wide; 25-85 cm long. **Peduncles** not disarticulating, persistent at maturity; 7-15 cm long; not partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** flexuous; 10-55 cm long; glabrous; glands absent. **Primary Branches** 1-3 or more per node; spreading; capillary; 4-40 cm long; glabrous; glands absent. **Pedicels** spreading; capillary; 2-30 mm long; scaberulous; glands absent. **Spikelets** 1-1.7 mm wide; 2-5 mm long. **Florets** 2-6. **Lower Glumes** 1.1-2 mm long; lanceolate; nerves 1; midnerves glabrous to scaberulous; apices acute. **Upper Glumes** 1.5-2.8 mm long; lanceolate to narrowly ovate; nerves 1; midnerves glabrous to scaberulous; apices obtuse. **Lemmas** 1.6-2.4 mm long; ovate; nerves 1; midnerves scaberulous; apices acute; dropping from rachillas at maturity. **Paleas** 1.2-2 mm long; ovate; nerves 2; midnerves glabrous; apices acute; persistent on rachillas at maturity. **Stamens** 3; anthers 0.3-0.8 mm long. **Caryopses** rectangular to oblong; 0.8-1 mm long; reddish-brown.

Eragostis hirsuta is a native species that grows in the sandy clay loams found in woodlands and along river margins usually in full to partial sun throughout Oklahoma (Peterson, 2003; Featherly, 1946). It is morphologically similar to *E. lugens* and *E. intermedia*; the three taxa forming and intergrading complex throughout the southern United States, with some individuals difficult to identify. *Eragrostis hirsuta* differs from *E. intermedia* by having wider leaf blades and

sheaths larger than the internodes. It differs from *E. lugens* by having hairier sheaths and longer and wider blades (Peterson, 2003).

***Eragrostis hypnoides* (Lam.) Britton, Stearns, & Poggenb. Teal Lovegrass**

Plants not aromatic; annuals; mat-forming; spreading by stolons; bearing perfect spikelets. **Stolons** elongate, more than 5 cm long; less than 3mm in diameter; wiry; naked; glabrous. **Culms** 5-20 cm tall when fertile; erect or geniculate; 0.3-0.5 mm in diameter; branched at all nodes. **Nodes** equal in diameter to internodes; stramineous or brown; not glaucous; glandular; not coated with a secretion; pilose, hairs dense or sparse. **Internodes** without a yellowish glandular band below each node; hollow; green; glabrous. **Leaves** strictly cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; shorter than internodes; green; not coated with a secretion; pilose, hairs not arising from swollen bases, sparse, 0.5-1 mm long, restricted to apices and forming a tuft; margins free, membranous or foliaceous, ciliate. **Ligules** ciliate; 0.3-0.5 mm long; apices truncate. **Collars** indistinct and typically not well differentiated from blades and sheaths; green or yellow-green; glabrous. **Blades** ascending or reflexed; linear; firm; flat or involute; narrower than sheaths; 1-1.5 mm wide; 1.5-4 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or pilose, hairs not arising from swollen bases or arising from pustules, dense or sparse; abaxial midribs not

conspicuous, not different in color; abaxial surfaces glabrous or pilose, hairs not arising from swollen bases or arising from pustules, sparse; apices acute; margins foliaceous, entire or scaberulous. **Panicles** terminal and axillary; open to loosely contracted; rachises and branches clearly visible; ovate; erect; greenish-yellow; 0.4-3 cm wide; 1-6 cm long. **Peduncles** not disarticulating, persistent at maturity; 0-3 cm long; partially enclosed in sheaths at anthesis; glabrous glands absent. **Rachises** straight; 1-5 cm long; setulose; glands absent. **Primary Branches** 1 or 2 per node; ascending; capillary; 0.1-0.5 cm long; whitish; glands absent; pulvini in axils present, sparsely hairy to glabrous. **Pedicels** appressed to ascending; capillary; 0.2-1 mm long; whitish; glands absent. **Spikelets** 1.4-3 mm wide; 3-16 mm long. **Florets**12-34. **Lower Glumes** 0.4-1.1 mm long; lanceolate; nerves 1-3; midnerves scabrous; apices acute. **Upper Glumes** 0.7-1.5 mm long; ovate to lanceolate; nerves 3; lateral ones apically inconspicuous; midnerves scabrous; apices acute. **Lemmas** 1.5-2 mm long; ovate; nerves 3; midnerves glabrate to pubescent; apices acuminate; dropping from rachillas at maturity. **Paleas** 0.5-1.3 mm long; ovate; nerves 2; midnerves scaberulous; apices acute to obtuse; persistent on rachillas at maturity. **Stamens** 2; anthers 0.2-0.3 mm long. **Caryopses** ellipsoid; 0.4-0.6 mm long; tan.

Eragrostis hypnoides is a native species that occupies sandy riverbanks and other disturbed sites. Its occurrence has not been documented in the Panhandle or the northwest corner of Oklahoma (Hoagland et al., 2004). In North America, its range extends from Canada to Argentina (Peterson, 2003).

***Eragrostis intermedia* Hitchc. Plains Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 30-10 cm tall; erect to ascending; 1-3 mm in diameter; **Nodes** slightly constricted; stramineous; not glaucous; not glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish band below each node; solid; yellow or yellowish to light green with some purple streaking; glabrous. **Leaves** primarily basal or both cauline and basal. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back; equal to or longer than internodes; stramineous to green or reddish gold; not coated with a secretion; margins pilose to glabrate at summits, hairs not arising from swollen bases, sparse, 1-1.5 mm long. **Ligules** ciliate; 1-5.5 mm long; apices acute. **Collars** conspicuously forming a yellowish band; glabrous; **Blades** ascending; linear; firm; involute; equal to or wider than sheaths at middles; 1- 3.5 mm wide; 5-20 (40) cm long; adaxial surfaces scabrous behind ligules; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous, smooth; apices attenuate; margins involute. **Panicles** only terminal; open, spreading and diffuse; ovate; erect; grey-green to reddish; 5-25 cm wide; 10-50 cm long. **Peduncles** not disarticulating, persistent at maturity; 3-13 cm long; partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 7-40 cm long; glabrous; glands absent. **Primary Branches** 1-3 per node; spreading; capillary; 4-25 cm long; glands absent; pulvini in axils present, pubescent. **Pedicels** spreading; capillary; 2-14 mm long; glabrous; glands absent. **Spikelets** 1-2 mm wide; 2.5-

5.7 mm long. **Florets** 2-9. **Lower Glumes** 0.7-1.5 mm long; lanceolate; nerves 1, midnerves scabrous; apices acute. **Upper Glumes** 1.2-1.8 mm long; ovate; nerves 1; midnerves scabrous. **Lemmas** 1.2 2 mm long; ovate; nerves 1; midnerves scaberulous; apices acute; dropping from rachillas at maturity. **Paleas** 1.4-2.1 mm long; lanceolate; nerves 2; midnerves ciliolate; apices acute to obtuse; persistent on rachillas at maturity. **Stamens** 3; anthers 0.3-0.4 mm long; **Caryopses** rectangular; 0.6-0.8 mm long; brown to tan.

Occurring as solitary plants in tallgrass prairies, *E. intermedia* is a native species found in sandy and rocky soils often in disturbed areas throughout the state, but primarily in the eastern half. In North America, it is considered to be a good forage grass for livestock (Tyrl et al., 2008). This species is morphologically similar to *E. hirsuta* and *E. lugens*; the three form a complex with intermediates encountered throughout the southern United States. Harvey (1975) submerged *E. intermedia* and *E. lugens*, but Peterson (2003) recognized it as distinct. The two differ in spikelet width, lower glume length and caryopsis grooves. *Eragrostis intermedia* and *E. hirsuta* differ in blade width and sheath length.

***Eragrostis japonica* (Thunb.) Trin. Pond Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 45-90 cm tall; erect or occasionally geniculate; 1.7-2.3 mm in diameter; unbranched or branched at lower nodes. **Nodes** equal in diameter to internodes;

brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; stramineous; glabrous. **Leaves** primarily cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back; shorter than internodes; green; not coated with a secretion; glabrous; margins free, foliaceous or occasionally membranous, entire. **Ligules** membranous; erose; 0.3-0.5 mm long; apices truncate. **Collars** indistinct and typically not well differentiated from blades and sheaths; yellow-green; glabrous. **Blades** appressed or ascending; linear; flat or occasionally involute; wider or narrower than sheaths; 2-5 mm wide; 15-25 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or scaberulous; abaxial midribs somewhat conspicuous; pale green; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire or scaberulous. **Panicles** only terminal; spicate, pedicels and rachises not visible; lanceolate; erect; yellow-green; 2-8 cm wide; 15-40 cm long. **Peduncles** not disarticulating, persistent at maturity;1-5 cm long; partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 10-40 cm long; glabrous; glands absent. **Primary Branches** 3 or more per node; appressed; capillary; 2-10 cm long; glabrous; glands absent; pulvini in axils present, glabrous; **Pedicels** appressed; capillary; 0.5-1.5 mm long; glabrous; glands absent. **Spikelets** 0.8-1.3 mm wide; 2.2-3.8 mm long. **Florets**4-12. **Lower Glumes** 0.6-1 mm long; ovate; midnerves inconspicuous; apices acute. **Upper Glumes** 0.4-0.8 mm long; ovate to lanceolate; midnerves inconspicuous; apices acute. **Lemmas** 0.9-1.2 mm long; ovate; nerves 3; midnerves apically inconspicuous; apices acute;

dropping from rachillas at maturity. **Paleas** 0.6-0.8 mm long; ovate; nerves 2; midnerves apically scabrous; apices acute; dropping from rachillas at maturity. **Stamens** 2; anthers 0.1-0.2 mm long. **Caryopses** obovoid; 0.3-0.4 mm long; reddish-brown.

Eragrostis japonica has an obscure origin, but is known to have been introduced from the tropics of the Eastern Hemisphere. It has naturalized in the southeastern part of Oklahoma in wet areas and along stream margins (Hoagland et al., 2004). In North America, it is established in the Gulf Coast region. The taxonomic synonym *E. glomerata* may be encountered in older literature (Peterson, 2003; Tyrl, 2001).

***Eragrostis lehmanniana* Nees Lehmann's Lovegrass, Knietjiegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 50-75 cm tall; conspicuously geniculate or erect; 0.7-1.8 mm in diameter; branched at lower nodes and occasionally branched at upper nodes. **Nodes** slightly constricted; stramineous or brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; solid; green or purplish green or reddish green or stramineous; glabrous. **Leaves** primarily basal or both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back; shorter than internodes; green or purplish or reddish green; not coated

with a secretion; pilose or occasionally glabrous, hairs not arising from swollen bases, sparse, 1-4 mm long, restricted to apices and forming a tuft; margins free, membranous, entire. **Ligules** ciliate; 0.2-0.5 mm long; apices truncate. **Collars** conspicuous; yellow-green; glabrous or pilose at margins, hairs dense. **Blades** ascending; linear; firm; involute or occasionally flat; equal to or narrower than sheaths; 1.2-3 mm wide; 6-17 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or distally scaberulous and/ or pilose behind ligules, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous; apices acute or attenuate; margins foliaceous, scaberulous. **Panicles** only terminal; open and diffuse; oblong; erect; purplish green; 1.5-8 cm wide; 7-30 cm long. **Peduncles** not disarticulating, persistent at maturity; 2-20 cm long; some branches partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** flexuous; 5-20 cm long; glabrous; glands absent. **Primary Branches** 1 or 2 per node; appressed to spreading; capillary; 2-10 cm long; glabrous; glands absent; pulvini glabrous. **Pedicels** ascending; capillary; 0.5-5 mm; glabrous to lightly scaberulous; glands absent. **Spikelets** 0.8-1.2 mm wide; 5-14 mm long. **Florets** 4-12. **Lower Glumes** 1-1.5 mm long; lanceolate; nerves inconspicuous; midnerves glabrous; apices acute. **Upper Glumes** 1.3-2 mm long; lanceolate; nerves inconspicuous; midnerves glabrous; apices acute. **Lemmas** 1.5-1.7 mm long; ovate; nerves 3, inconspicuous; midnerves glabrous; apices obtuse; dropping from rachillas at maturity. **Paleas** 1.4-1.7 mm long; ovate; nerves 2; midnerves glabrous; apices obtuse; persistent on rachillas at maturity. **Stamens**

3; anthers 0.6-0.9 mm long. **Caryopses** ellipsoid to obovoid; 0.6-0.8 mm long; light brown.

Eragrostis lehmanniana is known only from five collections in the central portion of the state (Hoagland et al., 2004). Introduced for erosion control from Africa, it is now somewhat of a problem in other areas of North America due to its tendency to displace native species. It is normally encountered sandy calcareous soils and is often found in shortgrass prairies and dry areas in the southwestern quarter of the United States (Peterson, 2003).

***Eragrostis lugens* Nees Plains Lovegrass, Mourning Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 35-90 cm tall; erect; 1-1.2 mm in diameter; unbranched. **Nodes** equal in diameter to internodes or slightly constricted; stramineous or brown or purplish green or reddish green; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; green or stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; keeled or rounded on back; usually shorter than internodes; green or purplish or occasionally reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense or sparse, 1-4 mm long, restricted to apices and forming a tuft; margins free, membranous, entire or ciliate or

pustulate -ciliate. **Ligules** ciliate; 0.2 mm long; apices truncate. **Collars** conspicuous or indistinct and not well differentiated from blades and sheaths; green or yellow-green; glabrous or pilose at margins, hairs dense or sparse. **Blades** ascending or curled; linear; firm or lax; typically flat or involute; equal to or narrower than sheaths; 1-3 mm wide; 8-20 cm long; relatively uniform in length along culms; adaxial surfaces pilose or hirsute, hairs not arising from swollen bases or arising from pustules, dense or sparse; abaxial midribs conspicuous or not conspicuous, not different in color or pale green; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire or scaberulous. **Panicles** only terminal; open; ovate; erect; reddish green; 8-20 cm wide; 16-28 cm long. **Peduncles** not disarticulating, persistent at maturity; 2-6 cm long; partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** flexuous; 12-22 cm long; glabrate; glands absent. **Primary Branches** 1 or 2 per node; ascending; capillary; 0.6-15 cm long; ciliolate; glands absent; pulvini in axils present, pubescent. **Pedicels** spreading; wavy; capillary; 1.5-6 mm long; ciliolate to scaberulous; glands absent. **Spikelets** 0.5-1.3 mm wide; 2-5 mm long. **Florets**2-7. **Lower Glumes** 0.6-1 mm long; lanceolate; nerves 1; midnerves ciliolate; apices acute. **Upper Glumes** 1.1-1.4 mm long; ovate; nerves 1; midnerves ciliolate; apices acute. **Lemmas** 1.2-1.8 mm long; ovate; nerves 3; midnerves scabrous; apices acute; dropping from rachillas at maturity. **Paleas** 1.1-1.7 mm long; ovate; nerves 2; midnerves scabrous; apices acute; persistent on rachillas at maturity. **Stamens** 3; anthers 0.2-0.7 mm long. **Caryopses** obovoid; 0.5-0.6 mm long, reddish-brown to opaque white.

Eragrostis lugens is a native species that grows on sandy soils or prairies and along river banks in the eastern half of the state (Peterson, 2003; Hoagland et al., 2004). It is morphologically quite similar to *E. intermedia* with which it was combined by Harvey (1975). Peterson (2003), however, considered them different species. They are distinguished by differences in spikelet width, lower glume length, and grooving of their caryopses. In North America, it is found in the Gulf Coast region.

***Eragrostis minor* Host Little Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 15-25 cm tall; decumbent, geniculate or rarely erect; 0.5-1 mm in diameter; unbranched or branched at lower nodes. **Nodes** equal in diameter to internodes or sometimes slightly constricted; purplish green or dark brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** occasionally with a yellowish glandular band below each node; hollow; purplish green, reddish green or stramineous; glabrous. **Leaves** primarily cauline. **Sheaths** with glandular pits or sometimes crateriform glands on midnerves; rounded on back or slightly keeled; shorter than internodes; green, purplish or reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, 2-3 mm long, restricted to apices and typically forming a tuft, or distributed from bases to apices; margins free, membranous, entire or sparsely ciliate. **Ligules** ciliate; 0.2-0.5 mm long; apices

truncate. **Collars** conspicuous or indistinct and not well differentiated from blades and sheaths; yellow-green; glabrous or pilose at margins, hairs sparse. **Blades** ascending or spreading; linear; flat or involute upon drying; wider or narrower than sheaths; 2-4 mm wide; 2-8 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or pilose, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, pale green; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire and always with crateriform glands present especially near blade bases. **Panicles** only terminal; open; ovate; erect; stramineous; 2-10 cm wide; 5-12 cm long. **Peduncles** not disarticulating, persistent at maturity; 1-3 cm long; lower ones sometimes partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** slightly wavy to straight; 5-11 cm long; glabrous to slightly scaberulous on margins; glands absent. **Primary Branches** 1 per node; ascending; slender; 0.5-6 cm long; glabrous; pulvini in axils present, glabrous or hairy. **Pedicels** ascending; capillary; 1-4 mm long; glabrous; crateriform-like glands present. **Spikelets** 1.4-2.4 mm wide; 4-10 mm long. **Florets** 5-21**. Lower Glumes** 1-1.6 mm long; ovate; nerves 1; midnerves slightly scaberulous; apices acute. **Upper Glumes** 1.3-1.8 mm long; ovate; nerves 3; midnerves slightly scaberulous; apices acute. **Lemmas** 1.4-2 mm long; broadly ovate; nerves 3; midnerves glabrous to occasionally glandular; apices acute; dropping from rachillas at maturity. **Paleas** 1.3-1.7 mm long; ovate; nerves inconspicuous; margins ciliolate; apices obtuse; persistent on rachillas at maturity. **Stamens** 2; anthers 0.2-0.3 mm long. **Caryopses** elliptic; 0.4-0.7 mm long; light brown.

Eragrostis minor is a European species that has naturalized in gravelly right-of-ways, railroad yards and disturbed areas (Peterson, 2003). It has only been collected 8 times, all in the body of Oklahoma (Hoagland et al., 2004). General distribution in North America is across the contiguous United States and into southern Canada (Peterson, 2003). The binomial, *E. poaeoides*, may be encountered in older literature (Tyrl, 2001).

***Eragrostis pectinacea* (Michx.) Nees Tufted Lovegrass, Spreading Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 10-40 cm tall; geniculate or occasionally decumbent; 0.7-1.3 mm in diameter; branched at lower nodes or unbranched. **Nodes** equal in diameter to internodes or occasionally slightly constricted; dark brown or occasionally purplish green; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; solid or hollow; typically stramineous or occasionally reddish to purplish green; glabrous. **Leaves** primarily cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; keeled; shorter than internodes; green or rarely purplish to reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, 1-3 mm long, restricted to apices and forming a tuft; margins free,

foliaceous or occasionally membranous, entire. **Ligules** ciliate; 0.3-0.5 mm long; apices truncate. **Collars** typically conspicuous; yellow-green; pilose at margins, hairs dense. **Blades** ascending; linear; flat or involute; wider or narrower than sheaths; 1-4 mm wide; 7-15 cm long; relatively uniform in length along culms; adaxial surfaces glabrous or scaberulous; abaxial midribs somewhat conspicuous; pale green; abaxial surfaces glabrous; apices attenuate or occasionally filiform; margins foliaceous, entire or scaberulous. **Panicles** only terminal; loosely contracted, pedicels and rachises clearly visible; ovoid to oblong; erect; lead green; 3-15 cm wide; 5-22 cm long. **Peduncles** not disarticulating, persistent at maturity; 4-10 cm long; not enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** flexuous; 8-20 cm long; glabrous to scaberulous; glands absent. **Primary Branches** 3 or more per node; ascending; capillary; 0.6-8 cm long; glabrous to scaberulous; glands absent; pulvini in axils present, sparsely hairy to glabrous. **Pedicels** appressed to ascending; capillary; 1-7 mm long; scaberulous; glands absent. **Spikelets** 1-1.2 mm wide; 3.5-7.5 mm long**. Florets** 6-13. **Lower Glumes** 0.7-1.5 mm long; lanceolate; nerves 1; midnerves glabrous to scaberulous; apices acute. **Upper Glumes** 1-1.6 mm long; lanceolate; nerves 1; midnerves glabrous to scaberulous; apices acute. **Lemmas** 1-2.2 mm long; ovate to lanceolate; nerves 3; midnerves ciliolate; apices acute; dropping from rachillas at maturity. **Paleas** 1-2 mm long; ovate; nerves 2; midnerves ciliolate; apices obtuse; persistent on rachillas at maturity. **Stamens** 3; anthers 0.2-0.4 mm long. **Caryopses** oblong; 0.7-1.1 mm long; pale resinous gold.

Eragrostis pectinacea is a native species that grows in dry riverbeds, along roadsides and in cultivated fields throughout Oklahoma (Hoagland et al., 2004). In North America, it is distributed from southern Canada to Argentina (Peterson, 2003).

***Eragrostis pilosa* (L.) Beauv. India Lovegrass**

Plants not aromatic; annuals; cespitose; bearing perfect spikelets. **Culms** 25-45 cm tall; geniculate or erect; 0.7-1.3 mm in diameter; branched at lower nodes. **Nodes** equal in diameter to internodes or occasionally slightly constricted; dark brown or occasionally purplish green; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; typically stramineous or occasionally purplish or reddish green; glabrous. **Leaves** primarily cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; keeled; longer than or equal to internodes; green or rarely purplish to reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, 2-3 mm long, restricted to apices and forming a tuft; margins free, foliaceous or occasionally membranous, entire. **Ligules** ciliate; 0.3-0.5 mm long; apices truncate. **Collars** typically conspicuous; yellow-green or brown; pilose at margins, hairs dense. **Blades** ascending; linear; flat or involute; wider or narrower than sheaths; 0.5-2 mm wide; 3-7 cm long; relatively uniform in length along culms; adaxial surfaces

glabrous or scaberulous; abaxial midribs somewhat conspicuous, pale green; abaxial surfaces glabrous; apices attenuate; margins foliaceous, entire or scaberulous. **Panicles** only terminal; loosely contracted, rachises and branches clearly visible; elliptic to oblong; erect; lead green; 2-12 cm wide; 6-30 cm long. **Peduncles** not disarticulating, persistent at maturity; up to 10 cm long; not partially enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 10-20 cm long; glabrous; glands absent. **Primary Branches** 3 or more per node; ascending; capillary; 1-10 cm long; glabrous; glands absent; pulvini in axils present, pilose. **Pedicels** spreading; capillary; 1-8 mm long; glabrous to minutely ciliolate; glands absent. **Spikelets** 0.7-1.7 mm wide; 2-7 mm long. **Florets** 3-11. **Lower Glumes** 1.5-3.5 mm long; narrowly ovate; nerves 1; midnerves scabrous; apices acute. **Upper Glumes** 2-4 mm long; narrowly ovate; nerves 1; midnerves scabrous; apices acute. **Lemmas** 1.2-2.2 mm long; ovate; nerves 3; midnerves scabrous; apices acute; dropping from rachillas at maturity. **Paleas** 1-1.5 mm long; ovate; nerves 2; midnerves scabrous; apices acute; dropping from rachillas at maturity. **Stamens** 3; 0.1-0.4 mm long. **Caryopses** ovoid; 0.5-0.9 mm long; reddish- tan.

Eragrostis pilosa is native to Eurasia, but naturalized throughout Oklahoma in disturbed areas, cultivated fields, and forest margins. In North America, it is found primarily in the eastern United States (Peterson, 2003).

***Eragrostis reptans* (Michx.) Nees Creeping Lovegrass**

Plants not aromatic; annuals; mat-forming; spreading by stolons; dioecious. **Stolons** elongate, more than 5 cm long; less than 3mm in diameter; wiry; naked; pilose, hairs dense. **Culms** 2-5 cm tall when fertile; ascending; 0.5 mm in diameter; branched or unbranched at lower nodes. **Nodes** equal in diameter to internodes; hidden by sheaths; brown; not glaucous; glandular; not coated with a secretion; pilose, hairs dense. **Internodes** without a yellowish glandular band below each node; hollow; green; pilose, hairs dense or sparse. **Leaves** strictly cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; longer than internodes; green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, distributed from bases to apices; margins free, membranous, entire. **Ligules** sparsely ciliate; 0.3-0.5 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths; green; pilose, hairs dense. **Blades** ascending or reflexed; linear or linear-lanceolate; firm; flat or involute; narrower than sheaths; 1-3 mm wide; 1-4 cm long; relatively uniform in length along culms; adaxial surfaces pilose, hairs not arising from swollen bases, dense; abaxial midribs not conspicuous, not different in color; abaxial surfaces pilose, hairs not arising from swollen bases, sparse; apices acute; margins foliaceous, entire or scaberulous. **Panicles** only terminal; staminate and pistillate inflorescences similar; spicate, rachises and branches not visible; globose; erect; yellow green to stramineous; 0.5-4 cm wide; 2-4 cm long. **Peduncles** not disarticulating, persistent at maturity; 0.5-5 cm long; some partially enclosed in sheaths at anthesis; pilose; glands not

apparent. **Rachises** straight; 1-2 cm long; pubescent; glands absent. **Primary Branches** hidden by spikelets; appressed; slender; pubescent; glands absent; pulvini in axils not conspicuous; sparsely pilose. **Pedicels** appressed. slender; 0.5-1.5 mm long; pilose; glands absent. **Spikelets** 1.8-4.7 mm wide; 3-12 mm long. **Florets** 5-19(33). **Lower Glumes** 0.8-1.6 mm long; ovate; nerves 1-3; midnerves sparsely hirsute to glabrous; apices acute. **Upper Glumes** 2-3.5 mm long; ovate; nerves 1-3; midnerves sparsely hirsute to glabrous; apices acute. **Lemmas**1.8-4 mm long; ovate; nerves 3; midnerves hirsute; apices acute; dropping from rachillas at maturity. **Paleas** 0.7-3.5 mm long; ovate; nerves 2; midnerves scaberulous; apices acute; dropping from rachillas at maturity. **Stamens** 3; anthers 1.4-2.2 mm long. **Caryopses** ellipsoid; 0.4-0.6 mm long; reddish-brown.

Eragrostis reptans is a native species that frequently inhabits wet sandy or gravely areas along rivers and lake margins across Oklahoma; however its presence has not been documented in the Panhandle (Hoagland et al., 2004). In North America, it grows primarily from the central United States to northern Mexico (Peterson, 2003). Harvey (1975) and other agrostologists have classified this taxon as *Neeragrostis reptans* (Michx.) Nicora. Nicora (1962) distinguished it from *Eragrostis* based on differences in epidermal and ovarian characters as well as its dioecious nature. Recent phylogentic studies by Ingram and Doyle (2004) have concluded that it would be better placed within *Eragrostis*, where the Flora of North America committee has maintained its position (Peterson, 2003).

***Eragrostis secundiflora* J.Presl. ssp.*oxylepis* (Torr.) S.D. Koch Red Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 15-70 cm tall; erect or occasionally geniculate ; 0.5-1.5 mm in diameter; unbranched or occasionally branched at lower nodes. **Nodes** equal in diameter to internodes; brown or reddish brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; solid or hollow; stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; shorter than internodes; grey-green or reddish green; not coated with a secretion; glabrous or pilose, hairs not arising from swollen bases, sparse, 1-5 mm long, distributed from bases to apices and forming a small tuft; margins free, membranous, entire. **Ligules** ciliate; 0.2 mm long; apices truncate. **Collars** conspicuous; reddish purple; glabrous or pilose at margins, hairs sparse. **Blades** ascending; grey-green or reddish green; linear; flat or involute; equal to or narrower than sheaths; 1-3 mm wide; 5-15 cm long; relatively uniform in length along culms; adaxial surfaces distally scaberulous or pilose behind ligules, hairs not arising from swollen bases, sparse; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous; apices attenuate; margins foliaceous, scaberulous. **Panicles** only terminal; densely

contracted, rachises and branches partially visible; elliptic to narrowly oblong; erect; stramineous to reddish purple; 1-15 cm wide; 3-30 cm long. **Peduncles** not disarticulating; persistent at maturity; 1-15 cm long; not enclosed in sheaths at anthesis; scaberulous; glands absent. **Rachises** straight; 5-20 cm long; glabrate; glands absent. **Primary Branches** 1 per node; ascending; capillary; 0.5-13 cm long; scaberulous; glands absent; pulvini in axils present, sparsely pilose. **Pedicels** appressed to ascending; capillary; 0-3 mm long; sparsely scabrous; glands absent. **Spikelets** 2-4.5 mm wide; 5-13 mm long; reddish purple. **Florets** 5-20. **Lower Glumes** 1.7-3 mm long; lanceolate; nerves 1; midnerves scaberulous; apices acuminate. **Upper Glumes** 2.2-4 mm long; lanceolate; nerves 1; midnerves scaberulous; apices acuminate. **Lemmas** 2.2-3.5 mm long; ovate; nerves 3; midnerves scaberulous; apices acute; persistent on rachillas at maturity. **Paleas** 1.5-3 mm long; ovate; merves 2; midnerves scaberulous; apices acute; persistent on rachillas at maturity. **Stamens** 2; anthers 0.3-0.6 mm long. **Caryopses** narrowly ovate; 1-1.4 mm long; tan.

Red lovegrass in North America has long been known as *E. oxylepis*. Systematic studies by Koch (1978), however, revealed that it is conspecific with the Central and South American *E. secundiflora*. North American plants are found throughout the south and are classified as ssp. *oxylepis.* Plants classified as ssp. *secundiflora* grow further south in Mexico and beyond. The binomial *E. beyrichii* is used in older treatments of North American grasses. This species occurs across Oklahoma in sandy soils and disturbed areas such as fencerows and road

margins. Forage value is recorded as low (Tyrl et al., 2008).

***Eragrostis sessilispica* Buckley Tumble Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 15-75 cm tall; erect or reclining; 1-1.5 mm in diameter; unbranched. **Nodes** slightly constricted; stramineous, purplish green or reddish green; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back; longer than internodes; green or rarely purplish or reddish green; not coated with a secretion; pilose, hairs not arising from swollen bases, dense, 2-3 mm long, restricted to apices and forming a tuft; margins free, membranous, entire. **Ligules** ciliate; 0.2 mm long; apices truncate. **Collars** conspicuous; green or reddish purple; pilose, hairs dense. **Blades** ascending or spreading; linear; flat or involute; equal to or narrower than sheaths; 2-3 mm wide; 8-30 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or distally scaberulous and/or pilose behind ligules, hairs not arising from swollen bases, dense; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous or rarely pilose, hairs sparse; apices attenuate; margins foliaceous, entire or scaberulous. **Panicles** only terminal; open; oblong; erect to reclining; stramineous to purplish-green; 8-30 cm wide; 18-80 cm long. **Peduncles** not disarticulating, persistent at maturity; up to 15 cm

long; partially enclosed in sheaths at maturity; glabrous; glands absent. **Rachises** straight to recurved; 10-75 cm long; glands absent. **Primary Branches** 1 per node; diverging; stout; 2-20 cm long; glabrous; glands absent. **Pedicels** absent. **Spikelets** 1.4-3 mm wide; 8-12 mm long. **Florets** 3-9. **Lower Glumes** 2.9-6 mm long; lanceoloate; nerves 1; midnerves glabrous; apices acute. **Upper Glumes** 3-7 mm long; lanceolate; nerves 1; midnerves glabrous; apices acuminate. **Lemmas** 3-6 mm long; lanceolate; nerves 3; midnerves glabrous; apices acute; persistent on rachillas at maturity. **Paleas** 2.4-4.6 mm long; lanceolate; nerves 2; midnerves ciliolate; apices acute; persistent on rachillas at maturity. **Stamens** 3; anthers 0.3-0.5 mm long. **Caryopses** ovoid; 1.2-1.5 mm long; brown.

Eragrostis sessilispica is a native species that occurs in sandy soils and grows in prairies, open woods or limestone mesas. Oklahoma collections are concentrated more heavily in the western and central portions of the state (Hoagland et al., 2004). In North America, its range extends from southwestern Kansas into northern Mexico (Peterson, 2003).

***Eragrostis spectabilis* (Pursh) Steud. Purple Lovegrass**

Plants not aromatic; perennials; cespitose and spreading by rhizomes; bearing perfect spikelets. **Rhizomes** knotty; typically producing aerial culms along entire length; less than 5 cm long; obliquely ascending; 3 mm or more in

diameter; scale leaves present; glabrous. **Culms** 30-110 cm tall; erect or ascending; 1.2-2 mm in diameter; unbranched. **Nodes** equal in diameter to internodes; stramineous or brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; hollow; stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; typically longer than internodes; green or occasionally purplish to reddish green; not coated with a secretion; pilose, hairs sometimes arising from pustules, dense or sparse, 3-5 mm long; distributed from bases to apices or restricted to apices and forming a tuft; margins free, membranous, ciliate. **Ligules** ciliate; 0.1-0.2 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths or rarely conspicuous; green or reddish purple; pilose, hairs dense. **Blades** ascending; linear; flat or involute upon drying; equal to or narrower than sheaths; 3-8 mm wide; 15-30 cm long; relatively uniform in length along culms; adaxial surfaces pilose, hairs not arising from swollen bases, dense, to 10 mm long, restricted to bases behind the ligules or rarely distributed from bases to apices; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous or rarely pilose ; hairs not arising from swollen bases, sparse; apices attenuate; margins foliaceous, scaberulous. **Panicles** only terminal; open; basal portions sometimes included in leaf sheaths; globose; erect; purplish-green; 15-40 cm wide; 15-60 cm long. **Peduncles** disarticulating and entire panicles breaking free from plants at maturity; 3-10 cm long; partially enclosed in sheaths at anthesis; glabrous; glands absent.

Rachises straight; 10-55 cm long; glabrate; glands absent. **Primary Branches** 2 or 3 per node; spreading; capillary; 5-20 cm long; glabrate; glands absent; pulvini in axils present, pubescent. **Pedicels** spreading; capillary; 1.5-15 mm long; scaberulous; glands absent. **Spikelets**1-2.5 mm wide; 4-7 mm long. **Florets** 7-10. **Lower Glumes** 1-2 mm long; ovate to lanceolate; nerves 1; midnerves scaberulous at apices; apices acute. **Upper Glumes**1.4-2.2 mm long; lanceolate; nerves1; midnerves scaberulous at apices; apices acute. **Lemmas** 1.5-2.5 mm long; ovate; nerves 3; midnerves apically scaberulous; apices obtuse; persistent on rachillas at maturity. **Paleas** 1.1-1.6 mm long; ovate; nerves 2; midnerves ciliolate; apices obtuse; persistent on rachillas at maturity. **Stamens** 2; anthers 0.3-0.4 mm long. **Caryopses** ellipsoidal; 0.6-0.7 mm long; brown.

Eragrostis spectabilis is a native species that is characteristic of sandy soils of prairies and open woodlands. Due to the conspicuous purple cast of its foliage and especially its inflorescence, plants are used as ornamentals. Oklahoma populations are frequently encountered in the western two-thirds of the state (Hoagland et al., 2004). In North America, purple lovegrass extends from southern Canada through the eastern part of the United States, into Mexico, Central America, and Belize (Peterson, 2003). Livestock eat the foliage although it is not considered to be a significant forage species (Tyrl et al, 2008).

***Eragrostis trichodes* (Nutt.) Wood Sand Lovegrass**

Plants not aromatic; perennials; cespitose; bearing perfect spikelets. **Culms** 45-150 cm tall; erect; 1.5-2.5 mm in diameter; unbranched. **Nodes** slightly constricted; stramineous or brown; not glaucous; glandular; not coated with a secretion; glabrous. **Internodes** without a yellowish glandular band below each node; solid or hollow; green, purplish to reddish green or stramineous; glabrous. **Leaves** both basal and cauline. **Sheaths** without glandular pits or crateriform glands on midnerves; rounded on back or slightly keeled; longer than internodes; green or purplish to reddish green; not coated with a secretion; pilose or occasionally glabrous, hairs not arising from swollen bases, dense, 1-4 mm long, restricted to apices and forming a tuft or rarely restricted to distal half; margins free, membranous, entire. **Ligules** ciliate; 0.1-0.2 mm long; apices truncate. **Collars** indistinct and not well differentiated from blades and sheaths; green or reddish purple; pilose at margins or rarely glabrous, hairs dense. **Blades** ascending or curled; linear; firm or lax; involute or flat; equal to or narrower than sheaths; 2-8 mm wide; 20-40 cm long; relatively uniform in length along culms; adaxial surfaces scaberulous or distally scaberulous and,/or pilose behind ligules, hairs not arising from swollen bases, dense; abaxial midribs not conspicuous, not different in color; abaxial surfaces glabrous or scaberulous; apices attenuate or filiform; margins foliaceous, scaberulous. **Panicles** only terminal; open; oblong, erect; stramineous to golden purple; 5-35 cm wide; 30-100 cm long, more than 2/3 length of entire plant. **Peduncles** not disarticulating at maturity, persistent; up

to 40 cm long; not enclosed in sheaths at anthesis; glabrous; glands absent. **Rachises** straight; 40-100 cm long; glabrous; glands absent. **Primary Branches** 1-3 or more per node; divergent; capillary; 2-35 cm long; glabrate; glands absent; pulvini in axils glabrous or hairy. **Pedicels** spreading; capillary; 2-22 cm long; scabrous; glands absent. **Spikelets** 1.4-2.5 mm wide; 3.8-10 mm long. **Florets** 5-10. **Lower Glumes** 1.8-3 mm long; narrowly ovate; nerves 1; margins minutely scabrous; apices acute. **Upper Glumes** 2-4 mm long; narrowly lanceolate; nerves 1; margins scabrous; apices acute. **Lemmas** 2.2-3.5 mm long; ovate; nerves 3; midnerves glabrate; apices acute; persistent on rachillas at maturity. **Paleas** 1.8-2.8 mm long; ovate; nerves 2; midnerves scabrous; apices acute; persistent on rachillas at maturity. **Stamens** 3; anthers 0.9-1.6 mm long. **Caryopses** rectangular; 0.8-1.1 mm long; dark brown.

Eragrostis trichodes, a native, is abundant in the sandy soils of the northwest corner of the state where it is found in shinnery oak grasslands and open woodlands, on stabilized sand dunes, and in disturbed areas such as roadsides. It is consumed by livestock and cures well, so it is sometimes a constituent of hayfields (Tyrl et al., 2008). Waterfall (1969) recognized variety *pilifera* (Scheele) Fernald and variety *trichodes* (Nutt.) Wood, however, consistent recognition of individuals of these two varieties is tenuous and use of these infraspecific taxa does not seem warranted. In addition to this classification, Hitchcock & Chase (1950) recognized *E. trichodes* and *E. pilifera* Scheele as two distinct species, and Peterson (2003) listed *E. pilifera* as a synonym of *E. trichodes*.

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CHAPTER 4

A PRELIMINARY INVESTIGATION OF THE TOXICITY OF *TEPHROSIA VIRGINIANA* (FABACEAE) IN OKLAHOMA POPULATIONS

ABSTRACT

An examination of the toxicity of six populations of *Tephrosia virginiana* (Fabaceae) in Oklahoma revealed all root extracts to exhibit 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. A literature review revealed 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 produced few statistically significant differences. Correlations between toxicity and edaphic factors were inconclusive.

INTRODUCTION

Commonly known as hoary pea (Ibrahim, 2000), goat's rue, catgut (Tyrl et al., 2008), and devil's shoestring (Swanton, 1928), *Tephrosia virginiana* is a member of the Fabaceae, or pea family. A native, perennial herb from woody rootstalks, it is distributed throughout the eastern half of the United States and extends westward to Iowa, and eastern Kansas, Oklahoma, and Texas. In Oklahoma, it is most common in the east, but

can be found throughout the state. *Tephrosia virginiana* is found in a variety of habitats from the understory of the Cross Timbers to the open prairie, but typically grows 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 produce legumes that are relished by wildlife (Tyrl et al., 2008).

The roots of *T. virginiana* growing in certain localities 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 useable cellular energy (Lindahl & Oberg, 1961). Throughout most of its natural range, these compounds are absent in the plants (Sievers et al., 1938). Toxic populations occur in the southeastern states and the populations with the highest toxicity found thus far occur in the Carrizo Sands area of Texas, a belt of fine sand of the Norfolk series extending in a northeasterly direction from Dimmit County on the Mexican border to Cass Co. and into the northeast corner of Arkansas (Sievers et al., 1938). Previous tests on the species have revealed that the toxins are primarily sequestered in the underground portions of the plants. The seeds, however, have been found to contain rotenone, even in plants that were not otherwise toxic (Sievers et al., 1938).

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,” he wrote, “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 the root of *T. viginiana* roots were macerated and soaked in tubs of water overnight, and then scattered into a creek prior to a picnic. 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 here. 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 so called ‘bald spots’ (where some factor had interfered with the normal development of the soil profile such as road cuts or areas of excessive runoff) or where the roots of *T. virginiana* were in close proximity to the roots other plants. These populations were not considered to be of much value for the commercial production of insecticide. The findings of Sievers and Russell thus contradict the historical accounts documenting fishkills 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 of *T. virginiana*; (3) collecting plants along with soil samples; (4) extracting from the roots the compound or compounds responsible for toxicity; and (5) conducting bioassays for toxicity.

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 woody rootstocks of 3 or 4 plants were collected from each of six locations in five counties: Adair, Atoka, Cherokee, Okmulgee and Osage (Figure 1, Table 1). 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 because of the difficulty encountered during initial attempts to pulverize the long, tough lateral roots and woody caudex. 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. Again following the protocol of Sievers (1938), extracts were standardized to be equivalent to 1.5g of ground sample per 100-mL of acetone solution in all samples. An acetone blank — a solution of acetone without any plant material included — was also used in the extraction as a control. All extracts were stored in a 25 ℃ +/- 1 ℃ room in foil-covered amber glass bottles between assays to reduce exposure to light. Surface soil samples collected from each site 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.).

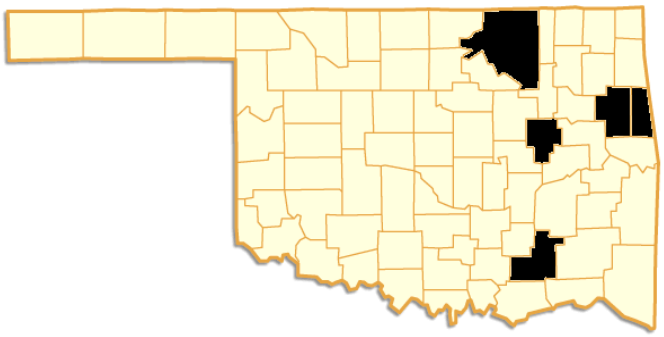


Figure 4.1 Counties in Oklahoma where specimens of *Tephrosia virgininana* were collected.

Table 4.1 Locality information for sampling sites where *Tephrosia virginiana* specimens were collected

	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 formulated water (USEPA, 2002). 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 ℃ +/- 1 ℃ with a 16/8 h light/dark cycle. Median lethal effects concentrations (48-h 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 given the availability of larval fish 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-h 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-h 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, where no mortality occurred. Because of the variability among the values generated from the replicate bioassays within sites (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-h LC_{50} values showing increases and decreases, whereas other extracts were more consistent (Table 2). On average, the Cherokee sample was the least toxic, and Adair Eagle Pass and Atoka were found to have equivalent 48-h LC_{50} values, as well as having the most consistent 48-h 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-h LC_{50} values. These data are displayed in Figure 2, along with the standard deviation. No relationships between toxicity and soil parameters — soil texture, pH, OM%, K index, or P index — were detected. The regression equations calculated were not significant.

Soil texture classes for the six sites are displayed in Figures 3, 4 and 5. Adair Gittin' Down Mtn. site and Atoka site had the most sand with 65% each, and Beggs had the least amount with 19%. Silt was the next largest category, making up approximately one third of the soil profile in each site, except for Beggs, which had 62%. Clay particles were the least represented in the soils, with the highest percentage (27%) found in

Adair Eagle Pass. Organic matter percentage was highest (23%) at Adair Gittin' Down Mtn. site, with all other values being below 12% (Figure 6). pH ranged between 5 and 6.7 for all samples, with Adair Eagle Pass site having the most acidic, and Adair Gittin' Down Mtn. having the most alkaline soils (Figure 7). The K indices (Figure 8) and P indices (Figure 9) of soils exhibited no variation of statistical significance across populations. All of the seven variables measured as part of the water chemistry were within a 'normal range' and there was little variation over time.

Table 4.2 48-h LC_{50} (mg/L) values values for Fathead minnows (*Pimephales promelas*) exposed to root extracts of *Tephrosia virginiana* from different six sites in Oklahoma. An acetone blank used as a control exhibited no toxicity.

	48-h LC_{50} values (mg/L)				
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

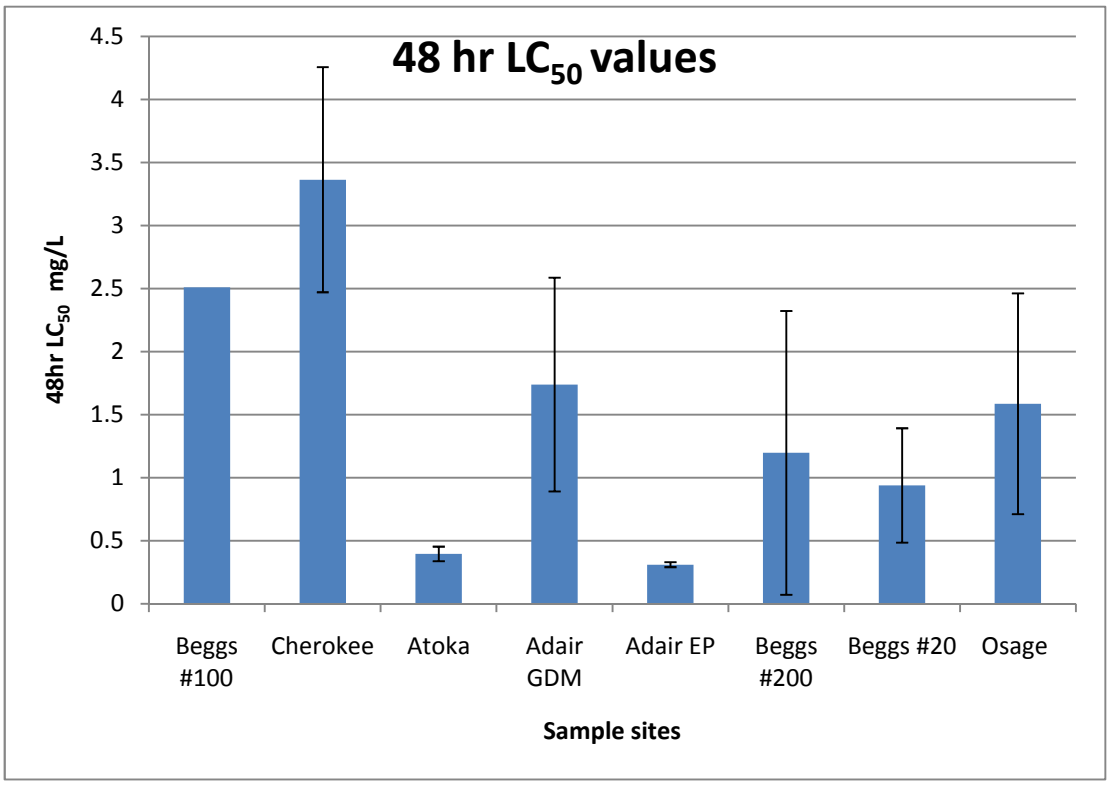


Figure 4.2 Average 48-h LC_{50} values for root extracts of *Tephrosia virginiana* from six sites in Oklahoma. Standard deviations are included.

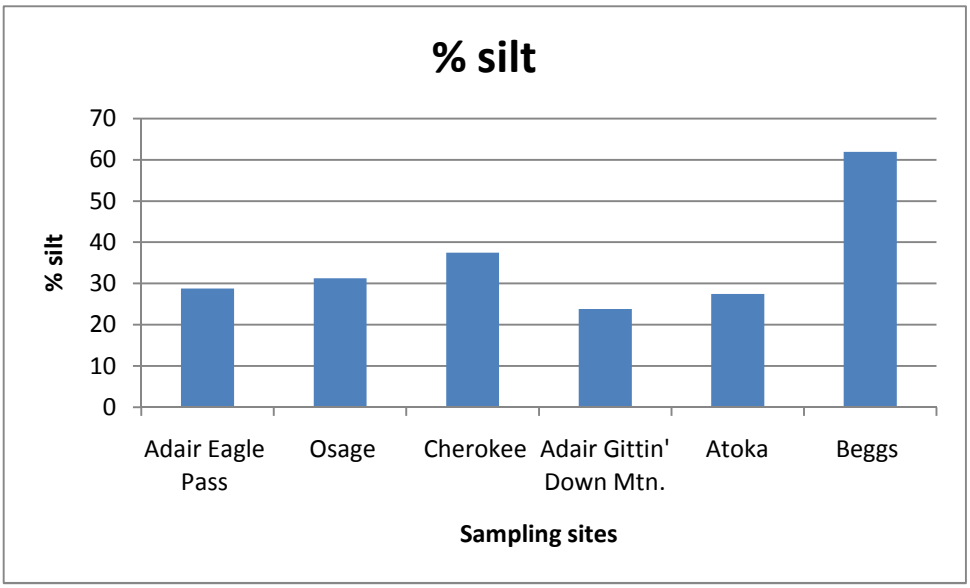


Figure 4.3 Silt percentages for six collection sites of *Tephrosia virginiana* in Oklahoma.

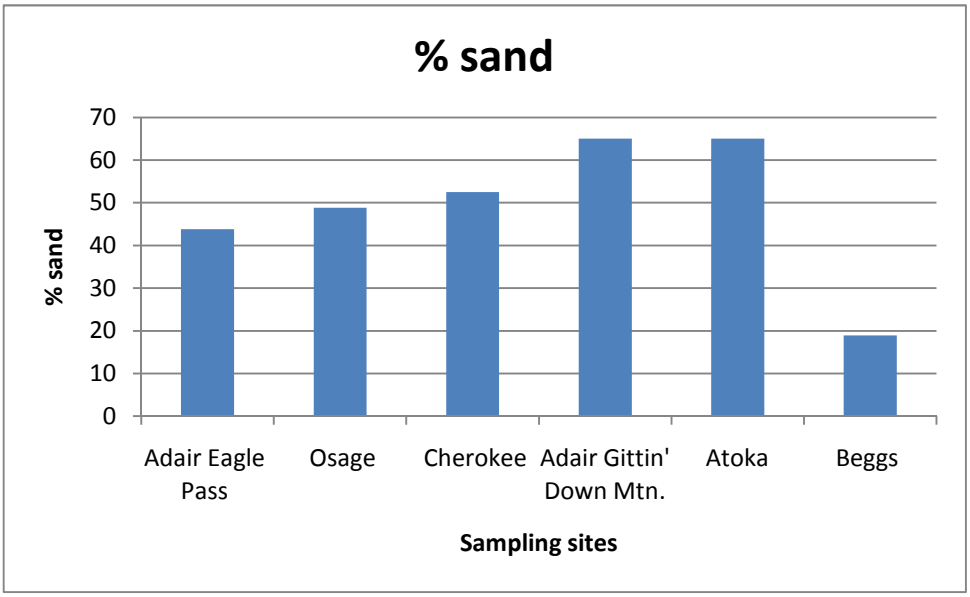


Figure 4.4 Sand percentages for six collection sites of *Tephrosia virginiana* in Oklahoma.

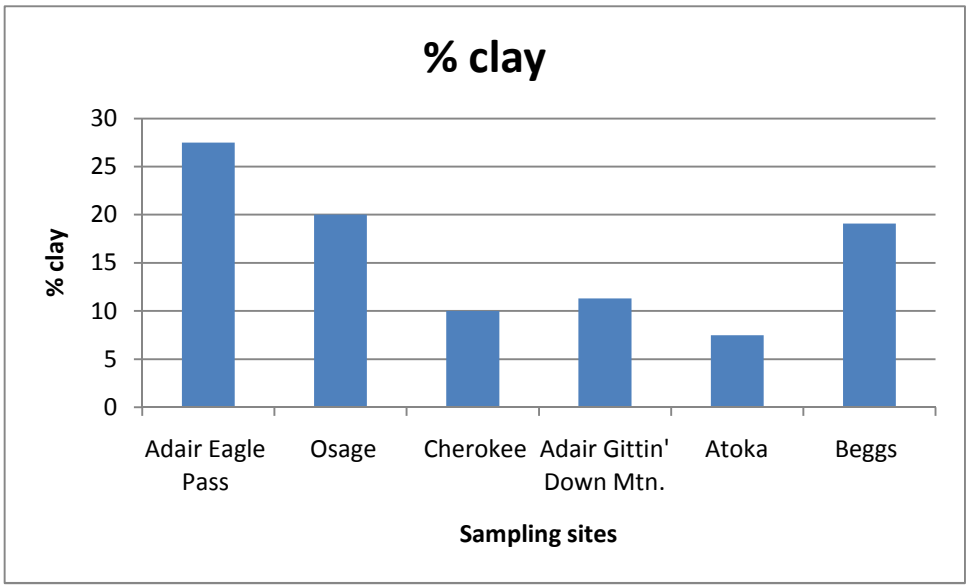


Figure 4.5 Clay percentages for six collection sites of *Tephrosia virginiana* in Oklahoma.

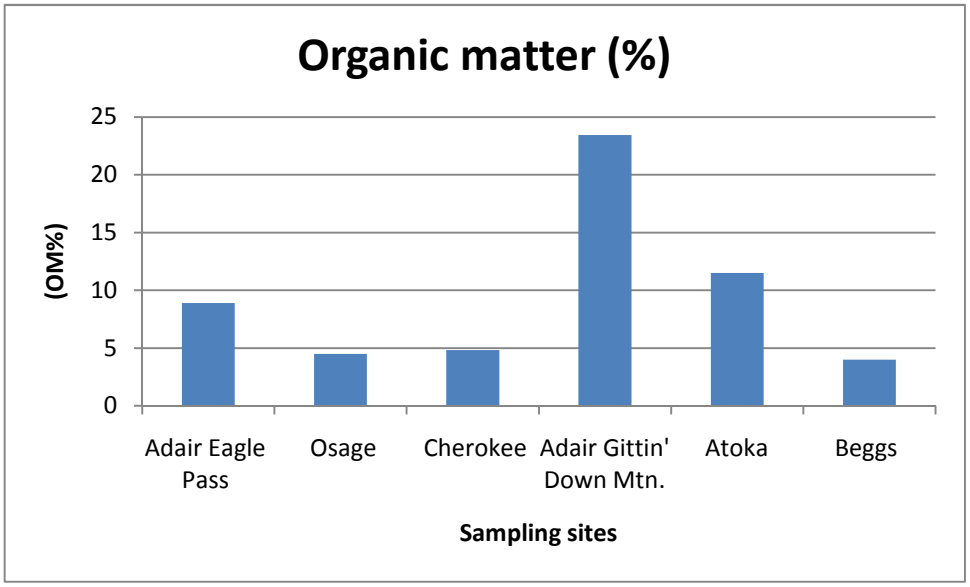
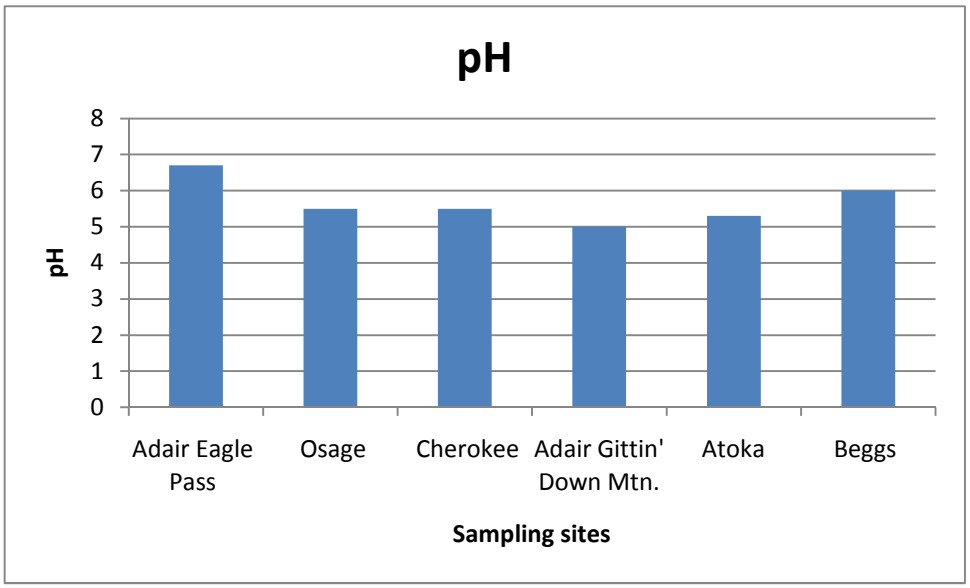


Figure 4.6 Percent of organic matter in soil samples from six sites occupied by *Tephrosia virginiana* in Oklahoma.



. Figure 4.7 pH of soil samples from six sites occupied by *Tephrosia virginiana* in Oklahoma.

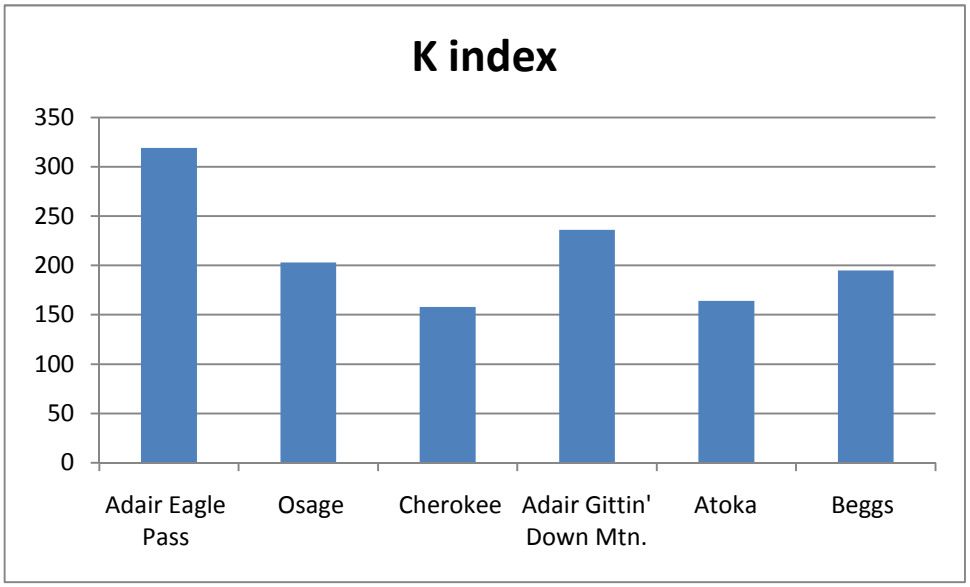


Figure 4.8 K indices of soil samples from six sites occupied by *Tephrosia virginiana* in Oklahoma.

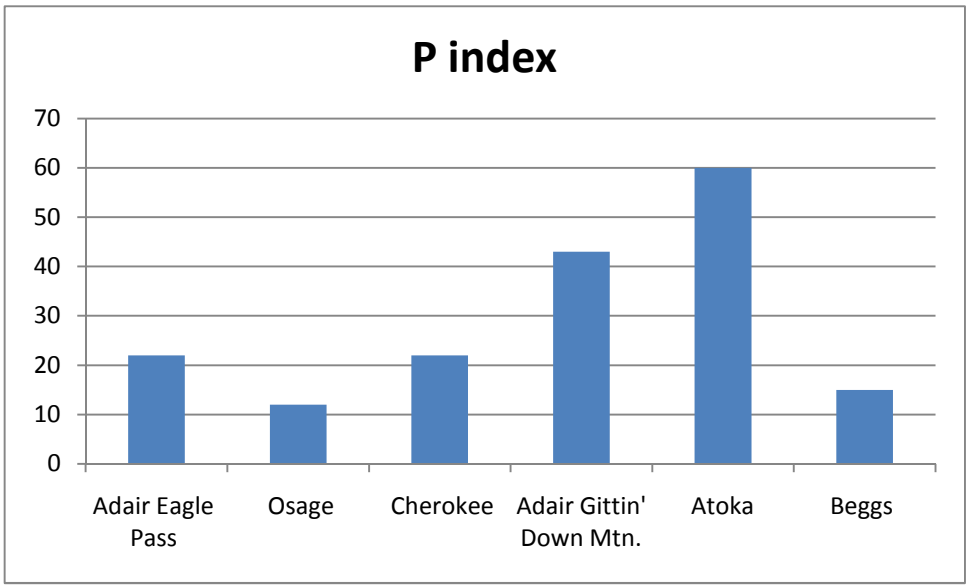


Figure 4.9 P indices of soil samples from six sites occupied by *Tephrosia virginiana* in Oklahoma.

DISCUSSION

All Oklahoma populations of *T. virginiana* tested in this study appear to contain a toxin or toxins. All extracts containing plant material produced mortality of larval flathead minnows in a standard laboratory bioassay (Table 2, Figure 2). 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.

It was hoped that it would be possible to determine whether there were differences in toxicity among the six populations and whether such differences if present might be related to edaphic factors as was reported by Sievers and coworkers (1938). The variability among the replicates within sites produced few statistically significant

differences among the six populations (Table 2). It is not known whether this reflects true biological similarity or not. 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 root 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 (Figure 2).

Sievers and his coworkers (1938) suggested that differences in toxicity might be related to soil and/or vegetative influences from other plants. It is possible that the sample size of only six populations in this study was too small to statistically measure a relationship between edaphic factors and toxicity. It was observed that some of the habitats where the samples were collected did have exposed substratum layers. Specifically, the Beggs collection site was directly beside a road cut and the Cherokee, Adair Eagle Pass, and Osage collection sites were in areas of excessive runoff due to steeply sloping topographic situations (Table 1). The silt content of the soils in which Atoka and Adair Eagle Pass populations were growing was similar (Figure 3); these two populations produced the most toxic samples. Atoka also had the highest content of sand, which brings to bear the comment previously stated by Jefferson Berryhill about sandier soils having more virulent populations (Foreman, 1938). The two sites with the highest organic matter content — Atoka and Adair Gittin' Down Mtn. were also the two

sites with the least amount of disturbance noted in the soil profile. Generally speaking, the results of this study are inconclusive with respect to edaphic factors.

In summary, all Oklahoma populations of *T. virginiana* tested in this study were found to be toxic. An understanding of the variability in toxicity among populations and the environmental factors possilbly related to toxicity requires that the work outlined here be repeated and extended.

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Appendix 1: Vascular Flora of the Sally Bull Hollow, Eagle Pass, and Workman Mountain tracts of the Ozark Plateau National Wildlife Refuge, Adair County, OK. Nomenclature, PLANTS symbolism, and exotic status within the United States follow that set forth by the PLANTS Database (USDA, NRCS, 2009). Taxa are arranged alphabetically by family, and species. Abundance is according to Palmer et al. (1995).

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
Acanthaceae	*Dicliptera brachiata* (Pursh) Spreng.	branched foldwing	occasional	Native	DIBR2
	Ruellia humilis Nutt.	fringed wild petunia	occasional	Native	RUHU
	Ruellia pedunculata Torr. ex A. Gray	stalked wild petunia	occasional	Native	RUPE4
Aceraceae	*Acer negundo* L.	boxelder	occasional	Native	ACNE2
	Acer rubrum L.	red maple	frequent	Native	ACRU
	Acer saccharum Marsh.	sugar maple	frequent	Native	ACSA3
Anacardiaceae	*Rhus aromatica* Aiton	fragrant sumac	frequent	Native	RHAR4
	Rhus copallinum L.	winged sumac	frequent	Native	RHCO
	Rhus glabra L.	clustered beaksedge	frequent	Native	RHGL3
	Toxicodendron radicans (L.) Kuntze	eastern poison ivy	frequent	Native	TORA2
Apiaceae	*Anthriscus caucalis* M. Bieb.	burchervil	occasional	Native	ANCA14
	Chaerophyllum tainturieri Hook.	hairyfruit chervil	occasional	Native	CHTA
	Daucus carota L.	Queen Anne's lace	occasional	Introduced	DACA6
	Eryngium yuccifolium Michx.	button eryngo	infrequent	Native	ERYU
	Osmorhiza longistylis (Torr.) DC.	longstyle sweetroot	occasional	Native	OSLO
	Polytaenia nuttallii DC.	Nutall's prairie parsley	frequent	Native	PONU4
	Sanicula canadensis L.	Canadian blacksnakeroot	occasional	Native	SACA15
	Spermolepis inermis (Nutt. ex DC.) Mathias & Constance	Red River scaleseed	occasional	Native	SPIN
	Taenidia integerrima (L.) Drude	yellow pimpernel	frequent	Native	TAIN
	Trepocarpus aethusae Nutt. ex DC.	whitenymph	occasional	Native	TRAE2
	Zizia aurea (L.) W.D.J. Koch	golden zizia	frequent	Native	ZIAU
Apocynaceae	*Amsonia tabernaemontana* Walter	eastern bluestar	occasional	Native	AMTA2

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Apocynum cannabinum L.	Indian hemp	occasional	Native	APCA
Aquifoliaceae	*Ilex decidua* Walter	possum haw	infrequent	Native	ILDE
Araceae	*Arisaema dracontium* (L.) Schott	green dragon	infrequent	Native	ARDR3
	Arisaema triphyllum (L.) Schott	Jack in the Pulpit	infrequent	Native	ARTR
Aristolochiaceae	*Asarum canadense* L.	Canadian wild ginger	infrequent	Native	ASCA11
Asclepiadaceae	*Asclepias tuberosa* L.	butterfly milkweed	infrequent	Native	ASTU
	Asclepias variegata L.	redring milkweed	occasional	Native	ASVA
	Asclepias verticillata L.	whorled milkweed	occasional	Native	ASVE
	Matelea baldwyniana (Sweet) Woodson	Baldwin's milkvine	occasional	Native	MABA3
	Matelea gonocarpos (Walter) Shinners	angularfruit milkvine	occasional	Native	MAGO
Aspleniaceae	*Asplenium platyneuron* (L.) Britton, Sterns & Poggenb.	ebony spleenwort	frequent	Native	ASPL
	Asplenium rhizophyllum L.	walking fern	occasional	Native	ASRH2
Asteraceae	*Achillea millefolium* L.	common yarrow	occasional	Introduced	ACMI2
	Ageratina altissima (L.) King & H. Rob. var. *altissima*	white snakeroot	occasional	Native	AGALA
	Ambrosia artemisiifolia L.	annual ragweed	frequent	Native	AMAR2
	Ambrosia bidentata Michx.	lanceleaf ragweed	occasional	Native	AMBI2
	Ambrosia psilostachya DC.	cuman ragweed	frequent	Native	AMPS
	Ambrosia trifida L.	great ragweed	frequent	Native	AMTR
	Ambrosia trifida L. var. trifida f. integrifolia (Muhl. ex Willd.) Fernald	great ragweed	infrequent	Native	AMTRT2
	Amphiachyris dracunculoides (DC.) Nutt.	prairie broomweed	frequent	Native	AMDR
	Antennaria parlinii Fernald	Parlin's pussytoes	frequent	Native	ANPA9
	Antennaria parlinii Fernald ssp. *fallax* (Greene) Bayer & Stebbins	Parlin's pussytoes	frequent	Native	ANPAF
	Arctium minus Bernh.	lesser burdock	occasional	Introduced	ARMI2

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Arnoglossum plantagineum Raf.	groovestem indian plantain	occasional	Native	ARPL4
	Bidens bipinnata L.	Spanish needles	occasional	Native	BIBI7
	Centaurea americana Nutt.	American starthistle	infrequent	Native	CEAM2
	Chrysopsis pilosa Nutt.	soft goldenaster	occasional	Native	CHPI8
	Cirsium altissimum (L.) Hill	tall thistle	occasional	Native	CIAL2
	Conoclinium coelestinum (L.) DC.	bluemist flower	infrequent	Native	COCO13
	Conyza canadensis (L.) Cronquist	Canadian horseweed	occasional	Native	COCA5
	Coreopsis lanceolata L.	lanceleaf tickseed	occasional	Native	COLA5
	Coreopsis palmata Nutt.	stiff tickseed	occasional	Native	COPA10
	Coreopsis pubescens Elliot	starticksеed	occasional	Native	COPU2
	Coreopsis tinctoria Nutt.	golden tickseed	occasional	Native	COTI3
	Echinacea pallida (Nutt.) Nutt.	pale purple coneflower	occasional	Native	ECPA
	Echinacea purpurea (L.) Moench	eastern purple coneflower	occasional	Native	ECPU
	Elephantopus carolinianus Raeusch.	Carolina elephant’s foot	occasional	Native	ELCA3
	Erigeron pulchellus Michx.	robin's plantain	frequent	Native	ERPU
	Erigeron strigosus Muhl. ex Willd.	prairie fleabane	frequent	Native	ERST3
	Eupatorium serotinum Michx.	lateflowering thoroughwort	occasional	Native	EUSE2
	Fleischmannia incarnata (Walter) King & H. Rob.	pink thoroughwort	infrequent	Native	FLIN2
	Gamochaeta purpurea (L.) Cabrera	spoonleaf purple everlasting	infrequent	Native	GAPU3
	Grindelia papposa G.L. Nesom & Suh	Spanish gold	occasional	Native	GRPA8
	Grindelia squarrosa (Pursh) Dunal	curlycup gumweed	occasional	Native	GRSQ
	Helenium amarum (Raf.) H. Rock	yellowdicks	occasional	Native	HEAM

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Helianthus ×laetiflorus Pers.	cheerful sunflower	infrequent	Native	HELA
	Helianthus hirsutus Raf.	hairy sunflower	occasional	Native	HEHI2
	Helianthus mollis Lam.	ashy sunflower	occasional	Native	HEMO2
	Heliopsis helianthoides (L.) Sweet	smooth oxeye	occasional	Native	HEHE5
	Heterotheca subaxillaris (Lam.) Britton & Rusby	camphorweed	occasional	Native	HESU3
	Heterotheca villosa (Pursh) Shinners	hairy false goldenaster	occasional	Native	HEVI5
	Hieracium gronovii L.	queendevil	occasional	Native	HIGR3
	Lactuca canadensis L.	Canada lettuce	occasional	Native	LACA
	Lactuca ludoviciana (Nutt.) Riddell	biannual lettude	occasional	Native	LALU
	Leucanthemum vulgare Lam.	oxeye daisy	occasional	Introduced	LEVU
	Liatris aspera Michx.	tall blazing star	occasional	Native	LIAS
	Liatris elegans (Walter) Michx.	pinkscale blazing star	occasional	Native	LIEL
	Liatris squarrosa (L.) Michx.	scaly blazing star	occasional	Native	LISQ
	Mikania scandens (L.) Willd.	climbing hempvine	occasional	Native	MISC
	Oligoneuron rigidum (L.) Small var. *rigidum*	stiff goldenrod	occasional	Native	OLRIR
	Packera glabella (Poir.) C. Jeffrey	butterweed	occasional	Native	PAGL17
	Packera obovata (Muhl. ex Willd.) W.A. Weber & A. Löve	roundleaf ragwort	occasional	Native	PAOB6
	Pluchea odorata (L.) Cass.	sweetscent	occasional	Native	PLOD
	Polymnia canadensis L.	whiteflower leafcup	occasional	Native	POCA11
	Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt	rabbit tobacco	occasional	Native	PSOB3
	Rudbeckia hirta L.	blackeyed susan	occasional	Native	RUHI2
	Rudbeckia triloba L.	browneyed susan	occasional	Native	RUTR2

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Solidago canadensis L.	Canada goldenrod	frequent	Native	SOCA6
	Solidago hispida Muhl. ex Willd.	hairy goldenrod	frequent	Native	SOHI
	Solidago missouriensis Nutt.	Missouri goldenrod	frequent	Native	SOMI2
	Solidago petiolaris Aiton	downy ragged goldenrod	frequent	Native	SOPE
	Solidago ulmifolia Muhl. ex Willd.	elmleaf goldenrod	frequent	Native	SOUL2
	Symphyotrichum anomalum (Engelm.) G.L. Nesom	manray aster	frequent	Native	SYAN2
	Symphyotrichum drummondii (Lindl.) G.L. Nesom var. *texanum* (Burgess) G.L. Nesom	Drummond's aster	frequent	Native	SYDRT
	Symphyotrichum oblongifolium (Nutt.) G.L. Nesom	aromatic aster	frequent	Native	SYOB
	Symphyotrichum patens (Aiton) G.L. Nesom var. *patens*	late purple aster	frequent	Native	SYPAP2
	Symphyotrichum turbinellum (Lindl.) G.L. Nesom	smooth violet prairie aster	occasional	Native	SYTU2
	Taraxacum officinale F.H. Wigg.	common dandelion	occasional	Introduced	TAOF
	Verbesina alternifolia (L.) Britton ex Kearney	wingstem	occasional	Native	VEAL
	Verbesina helianthoides Michx.	gravelweed	occasional	Native	VEHE
	Verbesina virginica L.	white crownbeard	occasional	Native	VEVI3
	Vernonia baldwinii Torr.	Baldwin's ironweed	occasional	Native	VEBA
Balsaminaceae	*Impatiens capensis* Meerb.	jewelweed	occasional	Native	IMCA
	Impatiens pallida Nutt.	pale touch me not	rare	Native	IMPA
Berberidaceae	*Podophyllum peltatum* L.	mayapple	frequent	Native	POPE
Betulaceae	*Ostrya virginiana* (Mill.) K. Koch	hophornbeam	occasional	Native	OSVI
Bignoniaceae	*Campsis radicans* (L.) Seem. ex Bureau	trumpetcreeper	frequent	Native	CARA2
	Catalpa speciosa (Warder) Warder ex Engelm.	Northern catalpa	infrequent	Native	CASP8
Boraginaceae	*Buglossoides arvensis* (L.) I.M. Johnst.	corn gromwell	infrequent	Introduced	BUAR3

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Cynoglossum virginianum L.	wild comfrey	infrequent	Native	CYVI
	Hackelia virginiana (L.) I.M. Johnst.	beggar's lice	occasional	Native	HAVI2
	Lithospermum canescens (Michx.) Lehm.	hoary puccoon	infrequent	Native	LICA12
	Lithospermum multiflorum Torr. ex A. Gray	manyflowered stoneseed	occasional	Native	LIMU
	Myosotis verna Engelm.	spring forget-me-not	occasional	Native	MYVE1
Brassicaceae	*Arabis canadensis* L.	sicklepod	infrequent	Native	ARCA
	Arabis laevigata (Muhl. ex Willd.) Poir.	smooth rockcress	occasional	Native	ARLA
	Arabis missouriensis Greene	green rockcress	occasional	Native	ARMI5
	Arabis shortii (Fernald) Gleason	short's rockcress	rare	Native	ARSH2
	Barbarea vulgaris W.T. Aiton	garden yellowrocket	occasional	Native	BAVU
	Cardamine concatenata (Michx.) Sw.	cutleaf toothwort	infrequent	Native	CACO26
	Cardamine parviflora L.	sand bittercress	infrequent	Native	CAPA12
	Lepidium densiflorum Schrad.	common pepperweed	infrequent	Native	LEDE
	Nasturtium officinale W.T. Aiton	watercress	infrequent	Introduced	NAOF
Campanulaceae	*Campanulastrum americanum* (L.) Small	American bellflower	infrequent	Native	CAAM18
	Lobelia cardinalis L.	cardinal flower	rare	Native	LOCA2
	Lobelia inflata L.	Indian tobacco	infrequent	Native	LOIN
	Lobelia spicata Lam.	palespike lobelia	infrequent	Native	LOSP
	Triodanis perfoliata (L.) Nieuwl.	clasping Venus' looking glass	occasional	Native	TRPE4
Capparaceae	*Cleome serrulata* Pursh	toothed spiderflower	infrequent	Native	CLSE2
Caprifoliaceae	*Sambucus nigra* L.	black elderberry	infrequent	Native	SANI4
	Symphoricarpos orbiculatus Moench	coralberry	abundant	Native	SYOR

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Viburnum prunifolium L.	blach haw	frequent	Native	VIPR
	Viburnum rufidulum Raf.	rusty blackhaw	frequent	Native	VIRU
Caryophyllaceae	*Dianthus armeria* L.	deptford pink	occasional	Introduced	DIAR
	Minuartia patula (Michx.) Mattf.	pitcher's stichwort	occasional	Native	MIPA6
	Saponaria officinalis L.	bouncing bet	occasional	Introduced	SAOF4
	*Silene stellata (*L.) W.T. Aiton	widowsfrill	occasional	Native	SIST
	Silene virginica L.	firepink	occasional	Native	SIVI4
	Stellaria media (L.) Vill.	common chickweed	occasional	Introduced	STME2
Celastraceae	*Euonymus atropurpureus* Jacq.	burningbush	infrequent	Native	EUAT5
Chenopodiaceae	*Chenopodium ambrosioides* L.	Mexican tea	infrequent	Introduced	CHAM
Clusiaceae	*Hypericum hypericoides* (L.) Crantz	St Andrew's cross	occasional	Native	HYHY
	Hypericum punctatum Lam.	spotted St. John's wort	occasional	Native	HYPU
Commelinaceae	*Commelina communis* L.	asiatic dayflower	occasional	Introduced	COCO3
	Commelina erecta L.	whitemouth dayflower	occasional	Native	COER
	Tradescantia ohiensis Raf.	bluejacket	occasional	Native	TROH
	Tradescantia ozarkana E.S. Anderson & Woodson	Ozark spiderwort	rare	Native	TROZ
Convolvulaceae	*Ipomoea coccinea* L.	redstar	occasional	Introduced	IPCO3
	Ipomoea pandurata (L.) G. Mey.	man of the earth	occasional	Native	IPPA
Cornaceae	*Cornus drummondii* C.A. Mey.	roughleaf dogwood	abundant	Native	CODR
	Cornus florida L.	flowering dogwood	abundant	Native	COFL2
	Nyssa sylvatica Marsh.	blackgum	occasional	Native	NYSY
Cupressaceae	*Juniperus virginiana* L.	Eastern redcedar	occasional	Native	JUVI
Cuscutaceae	*Cuscuta* L. (only to generic level)	dodder	occasional	Native	CUSCU

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
Cyperaceae	*Carex albicans* Willd. ex Spreng.	whitetinge sedge	occasional	Native	CAAL25
	Carex aureolensis Steudel	golden fruit sedge	occasional	Native	not in PLANTS database
	Carex cherokeensis Schwein.	Cherokee sedge	occasional	Native	CACH3
	Carex digitalis Willd.	slender woodland sedge	occasional	Native	CADI5
	Carex festucacea Schkuhr ex Willd.	fescue sedge	occasional	Native	CAFE3
	Carex grisea Wahlenb.	inflated narrowleaf sedge	occasional	Native	CAGR24
	Carex hirsutella Mack.	fuzzy wuzzy sedge	occasional	Native	CAHI6
	Carex meadii Dewey	Mead's sedge	occasional	Native	CAME2
	Carex oligocarpa Schkuhr ex Willd.	richwoods sedge	occasional	Native	CAOL2
	Carex retroflexa Muhl. ex Willd.	reflexed sedge	occasional	Native	CARE9
	Cyperus lupulinus (Spreng.) Marcks	Great Plains flatsedge	occasional	Native	CYLU2
	Eleocharis lanceolata Fernald	daggerleaf spikerush	occasional	Native	ELLA
	Rhynchospora glomerata (L.) Vahl	clustered beaksedge	occasional	Native	RHGL3
	Scirpus pendulus Muhl.	rufous bulrush	occasional	Native	SCPE4
	Scleria oligantha Michx.	littlehead nutrush	occasional	Native	SCOL2
Dryopteridaceae	*Dryopteris filix-mas* (L.) Schott	male fern	rare	Native	DRFI2
	Polystichum acrostichoides (Michx.) Schott	Christmas fern	frequent	Native	POAC4
	Woodsia obtusa (Spreng.) Torr.	bluntlobe cliff fern	occasional	Native	WOOB2
Ebenaceae	*Diospyros virginiana* L.	common persimmon	occasional	Native	DIVI5
	Elaeagnus angustifolia L.	Russian olive	infrequent	Introduced	ELAN
Ericaceae	*Vaccinium arboreum* Marsh.	farkleberry	abundant	Native	VAAR
Euphorbiaceae	*Acalypha ostryifolia* Riddell	pineland threeseed mercury	occasional	Native	ACOS

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	Acalypha rhomboidea Raf.	common threeseed mercury	occasional	Native	ACRH
	Chamaesyce missurica (Raf.) Shinners	prairie sandmat	occasional	Native	CHMI8
	Croton glandulosus L.	vente conmigo	occasional	Native	CRGL2
	Croton lindheimerianus Scheele	threeseed croton	occasional	Native	CRLI2
	Croton monanthogynus Michx.	prairie tea	occasional	Native	CRMO6
	Euphorbia corollata L.	flowering spurge	occasional	Native	EUCO10
	Euphorbia dentata Michx.	toothed spurge	occasional	Native	EUDE4
	Euphorbia spathulata Lam.	warty spurge	occasional	Native	EUSP
	Phyllanthus caroliniensis Walter	Carolina leafflower	infrequent	Native	PHCA9
Fabaceae	*Albizia julibrissin* Durazz.	silktree	infrequent	Introduced	ALJU
	Amphicarpaea bracteata (L.) Fernald	American hogpeanut	infrequent	Native	AMBR2
	Astragalus canadensis L.	Canadian milkvetch	occasional	Native	ASCA11
	Astragalus racemosus Pursh	cream milkvetch	infrequent	Native	ASRA2
	Baptisia bracteata Muhl. ex Elliot var. *leucophaea* (Nutt.) Kartesz & Gandhi	longbract wild indigo	occasional	Native	BABRL2
	Cercis canadensis L.	eastern redbud	frequent	Native	CECA4
	Chamaecrista fasciculata (Michx.) Greene	partridge pea	occasional	Native	CHFA2
	Chamaecrista nictitans (L.) Moench	sensitive partidge pea	occasional	Native	CHNI2
	Clitoria mariana L.	Atlantic pigeonwings	occasional	Native	CLMA4
	Dalea candida Michx. ex Willd.	white prairie clover	occasional	Native	DACA7
	Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald	Illinois bundleflower	occasional	Native	DEIL
	Desmodium canescens (L.) DC.	showy ticktrefoil	occasional	Native	DECA8
	Desmodium laevigatum (Nutt.) DC.	smooth ticktrefoil	occasional	Native	DELA

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	Desmodium pauciflorum (Nutt.) DC.	fewflower ticktrefoil	rare	Native	DEPA7
	Desmodium rotundifolium DC.	prostrate ticktrefoil	occasional	Native	DERO3
	Gleditsia triacanthos L.	honey locust	infrequent	Native	GLTR
	Glycyrrhiza lepidota Pursh	American licorice	infrequent	Native	GLLE
	Lespedeza cuneata (Dum. Cours.) G. Don	sericia lespedeza	occasional	Introduced	LECU
	Lespedeza frutescens (L.) Hornem.	shrubby lespedeza	occasional	Native	LEFR5
	Lespedeza hirta (L.) Hornem.	hairy lespedeza	occasional	Native	LEHI2
	Lespedeza procumbens Michx.	trailing lespedeza	occasional	Native	LEPR
	Lespedeza violacea (L.) Pers.	violet lespedeza	occasional	Native	LEVI6
	Lespedeza virginica (L.) Britton	slender lespedeza	occasional	Native	LEVI7
	Melilotus officinalis (L.) Lam.	yellow sweetclover	occasional	Introduced	MEOF
	Mimosa quadrivalvis L.	fourvalve mimosa	occasional	Native	MIQU2
	Orbexilum pedunculatum (Mill.) Rydb.	Sampson's snakeroot	infrequent	Native	ORPE
	Rhynchosia latifolia Nutt. ex Torr. & A. Gray	prairie snoutbean	infrequent	Native	RHLA5
	Senna marilandica (L.) Link	Maryland senna	infrequent	Native	SEMA11
	Strophostyles helvola (L.) Elliott	amberique bean	occasional	Native	STHE9
	Strophostyles leiosperma (Torr. & A. Gray) Piper	slickseed fuzzybean	occasional	Native	STLE6
	Stylosanthes biflora (L.) Britton, Sterns & Poggenb.	Mexican umbrella fern	occasional	Native	STBI2
	Tephrosia virginiana (L.) Pers.	Virginia tephrosia	occasional	Native	TEVI
	Trifolium campestre Schreb.	field clover	occasional	Introduced	TRCA5
	Trifolium dubium Sibth.	suckling clover	infrequent	Introduced	TRDU2
	Trifolium hybridum L.	alsike clover	occasional	Introduced	TRHY
	Trifolium repens L.	white clover	infrequent	Introduced	TRRE3

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	Vicia minutiflora F.G. Dietr.	pygmyflower vetch	occasional	Native	VIMI
Fagaceae	*Castanea pumila* (L.) P. Mill. var. *ozarkensis* (Ashe) Tucker	Ozark chinkapin	rare	Native	CAPUO
	Quercus alba L.	white oak	occasional	Native	QUAL
	Quercus falcata Michx.	southern red oak	abundant	Native	QUFA
	Quercus macrocarpa Michx.	buroak	abundant	Native	QUMA2
	Quercus marilandica Münch.	blackjack oak	abundant	Native	QUMA3
	Quercus muehlenbergii Engelm.	chinkapin oak	abundant	Native	QUMU
	Quercus prinoides Willd.	dwarf chinkapin oak	occasional	Native	QUPR
	Quercus rubra L.	Northern red oak	abundant	Native	QURU
	Quercus shumardii Buckley	Shumard's oak	abundant	Native	QUSH
	Quercus stellata Wangenh.	post oak	abundant	Native	QUST
	Quercus velutina Lam.	black oak	abundant	Native	QUVE
Fumariaceae	*Corydalis flavula* (Raf.) DC.	yellow fumewort	infrequent	Native	COFL3
	Dicentra cucullaria (L.) Bernh.	Dutchman's breeches	infrequent	Native	DICU
Geranianaceae	*Geranium carolinianum* L.	Carolina geranium	infrequent	Native	GECA5
	Geranium maculatum L.	spotted geranium	infrequent	Native	GEMA
Hamamelidaceae	*Hamamilis vernalis* Sarg.	Ozark witchhazel	occasional	Native	HAVE2
	Liquidambar styraciflua L.	sweetgum	occasional	Native	LIST2
Hippocastanaceae	*Aesculus glabra* Willd.	Ohio Buckeye	occasional	Native	AEGL
Hydrangeaceae	*Hydrangea arborescens* L.	wild hydrangea	infrequent	Native	HYAR
Iridaceae	*Belamcanda chinensis* (L.) DC.	blackberry lily	infrequent	Introduced	BECH
	Sisyrinchyium campestre E.P. Bicknell	prairie blue-eyed grass	occasional	Native	SICA9

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Juglandaceae	*Carya alba* (L.) Nutt.	mockernut hickory	abundant	Native	CAAL27
	Carya cordiformis (Wangenh.) K. Koch	bitternut hickory	abundant	Native	CACO15
	Carya glabra (Mill.) Sweet	pignut hickory	abundant	Native	CAGL8
	Carya ovalis (Wangenh.) Sarg.	red hickory	abundant	Native	CAOV3
	Carya ovata (Mill.) K. Koch	shagbark hickory	abundant	Native	CAOV2
	Carya texana Buckley	black hickory	abundant	Native	CATE9
	Juglans nigra L.	black walnut	abundant	Native	JUNI
Juncaceae	*Juncus interior* Wiegand	inland rush	occasional	Native	JUIN2
	Juncus marginatus Rostk.	grassleaf rush	occasional	Native	JUMA4
	Juncus secundus P. Beauv. ex Poir.	lopsided rush	occasional	Native	JUSE
	Juncus tenuis Willd.	poverty rush	occasional	Native	JUTE
	Luzula bulbosa (Alph. Wood) Smyth & Smyth	bulbous woodrush	occasional	Native	LUBU
Lamiaceae	*Cunila origanoides* (L.) Britton	common dittany	occasional	Native	CUOR
	Lamium purpureum L.	purple deadnettle	infrequent	Introduced	LAPU2
	Monarda bradburiana Beck	Eastern beebalm	occasional	Native	MOBR2
	Monarda citriodora Cerv. ex Lag.	lemon beebalm	occasional	Native	MOCI
	Monarda fistulosa L.	wild bergamot	occasional	Native	MOFI
	Monarda russeliana Nutt. ex Sims	redpurple beebalm	occasional	Native	MORU
	Perilla frutescens (L.) Britton	beefsteak plant	frequent	Introduced	PEFR4
	Prunella vulgaris L.	common selfheal	occasional	Native	PRVU
	Pycnanthimum tenuifolium Schrad.	narrowleaf mountain mint	occasional	Native	PYTE
	Salvia azurea L.	azure bluesage	occasional	Native	SAAZ

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	Salvia lyrata L.	lyreleaf sage	occasional	Native	SALY2
	Teucrium canadense L.	Canada germander	occasional	Native	TECA3
Lauraceae	*Sassafras albidum* (Nutt.) Nees	sassafras	frequent	Native	SAAL5
Liliaceae	*Allium canadense* L.	meadow garlic	infrequent	Native	ALCA3
	Camassia scilloides (Raf.) Cory	Atlantic camass	infrequent	Native	CACS5
	Erythronium albidum Nutt.	white fawnlily	occasional	Native	ERAL9
	Erythronium americanum Ker Gawl.	dogtooth violet	occasional	Native	ERAM5
	Erythronium rostratum W. Wolf	yellow troutlily	occasional	Native	ERRO5
	Maianthemum racemosum (L.) Link ssp. *racemosum*	feathery false lily of the valley	infrequent	Native	MARAR
	Narcissus tazetta L.	cream narcissus	infrequent	Introduced	NATA2
	Nothoscordum bivalve (L.) Britton	crowpoison	occasional	Native	NOBI2
	Polygonatum biflorum (Walter) Elliot	smooth Solomon's seal	infrequent	Native	POBI2
	Trillium viride Beck	wood wakerobin	occasional	Native	TRVI4
	Trillium viridescens Nutt.	tapertip wakerobin	occasional	Native	TRVI5
	Uvularia grandiflora Sm.	largeflower bellwort	rare	Native	UVGR
Lythraceae	*Cuphea viscosissima* Jacq.	blue waxweed	occasional	Native	CUVI
Malvaceae	*Callirhoe digitata* Nutt.	winecup	occasional	Native	CADI2
	Sida spinosa L.	prickly fanpetals	occasional	Native	SISP
Menispermaceae	*Cocculus carolinus* (L.) DC.	carolina coralbead	occasional	Native	COCA
Monotropaceae	*Monotropa uniflora* L.	Indianpipe	rare	Native	MOUN3
Moraceae	*Maclura pomifera* (Raf.) C.K. Schneid.	osage orange	occasional	Native	MAPO

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	Morus rubra L.	red mulberry	frequent	Native	MORU2
Nyctaginaceae	*Mirabilis albida* (Walter) Heimerl	white four o'clock	occasional	Native	MIAL4
Oleaceae	*Fraxinus americana* L.	white ash	frequent	Native	FRAM2
	Fraxinus pennsylvanica Marsh.	green ash	frequent	Native	FRPE
Onagraceae	*Gaura longiflora* Spach.	longflower beeblossom	occasional	Native	GALO3
	Ludwigia decurrens Walter	wingleaf primrose willow	occasional	Native	LUDE4
	Oenothera biennis L.	common evening primrose	occasional	Native	OEBI
	Oenothera macrocarpa Nutt.	bigfruit evening primrose	infrequent	Native	OEMA
Ophioglossaceae	*Botrychium biternatum* (Sav.) Underw.	sparseglobe bitternatum	occasional	Native	BOBOI
	Botrychium virginianum (L.) Sw.	rattlesnake fern	occasional	Native	BOVI
Orchidaceae	*Corallorhiza odontorhiza* (Willd.) Poir.	autumn coralroot	rare	Native	COOD7
	Spiranthes cernua (L.) Rich.	nodding ladie's tresses	infrequent	Native	SPCE
Oxalidaceae	*Oxalis dillenii* Jacq.	slender yellow woodsorrel	infrequent	Native	OXDI2
	Oxalis violaceae L.	violet woodsorrel	infrequent	Native	OXVI
Papaveraceae	*Sanguinaria canadensis* L.	bloodroot	occasional	Native	SACA13
Passifloraceae	*Passiflora incarnata* L.	purple passionflower	infrequent	Native	PAIN6
	Passiflora lutea L.	yellow passionflower	infrequent	Native	PALU2
Phytolaccaceae	*Phytolacca americana* L.	American pokeweed	occasional	Native	PHAM4
Pinaceae	*Pinus echinata* Mill.	shortleaf pine	infrequent	Native	PIEC2
Plantaginaceae	*Plantago aristata* Michx.	largebracted plantain	occasional	Native	PLAR3
	Plantago elongata Pursh	prairie plantain	occasional	Native	PLEL

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	Plantago lanceolata L.	narrowleaf plantain	occasional	Introduced	PLLA
	Plantago patagonica Jacq.	wooly plantain	occasional	Native	PLPA2
	Plantago rugelii Decne.	blackseed plantain	occasional	Native	PLRU
	Plantago virginica L.	Virginia plantain	occasional	Native	PLVI
Platanaceae	*Platanus occidentalis* L.	American sycamore	occasional	Native	PLOC
Poaceae	*Agrostis hyemalis* (Walter) Britton, Sterns & Poggenb.	winter bentgrass	occasional	Native	AGHY
	Agrostis perennans (Walter) Tuck.	upland bentgrass	occasional	Native	AGPE
	Aira elegans Willd. ex Kunth	annual silver hairgrass	occasional	Introduced	AIEL4
	Andropogon gerardii Vitman	big bluestem	occasional	Native	ANGE
	Andropogon ternarius Michx.	splitbeard bluestem	occasional	Native	ANTE2
	Aristida dichotoma Michx.	churchmouse threeawn	occasional	Native	ARDI4
	Aristida purpurea Nutt.	purple threeawn	occasional	Native	ARPU9
	Bromus pubescens Muhl. ex Willd.	hairy woodland brome	occasional	Native	BRPU6
	Chasmanthium latifolium (Michx.) Yates	Indian woodoats	occasional	Native	CHLA5
	Dactylis glomerata L.	orchard grass	occasional	Introduced	DAGL
	Danthonia spicata (L.) P. Beauv. ex Roem. & Schult.	poverty oat grass	frequent	Native	DASP
	Diarrhena americana P. Beauv.	American beakgrain	rare	Native	DIAM
	Diarrhena obovata (Gleason) Brandenburg	obovate beakgrain	occasional	Native	DIOB3
	Dichanthelium acuminatum (Sw.) Gould & C.A. Clark	tapered rosette grass	occasional	Native	DIAC2
	Dichanthelium laxiflorum (Lam.) Gould	openflower rosette grass	occasional	Native	DILA9
	Dichanthelium ravenelii (Scribn. & Merr.) Gould	Ravenel's rosette grass	frequent	Native	DIRA
	Digitaria cognata (Schult.) Pilg.	fall witchgrass	frequent	Native	DICO6

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	Digitaria violascens Link	violet crabgrass	occasional	Introduced	DIVI2
	Elymus hystrix L.	eastern bottlebrush grass	rare	Native	ELHY
	Elymus virginicus L.	Virginia wildrye	frequent	Native	ELVI3
	Eragrostis hirsuta (Michx.) Nees	bigtop lovegrass	frequent	Native	ERHI
	Eragrostis intermedia Hitchc.	plains lovegrass	frequent	Native	ERIN
	Eragrostis spectabilis (Pursh) Steud.	purple lovegrass	frequent	Native	ERSP
	Festuca subverticillata (Pers.) Alexeev	nodding fescue	frequent	Native	FESU3
	Glyceria striata (Lam.) Hitchc.	fowl mannagrass	occasional	Native	GLST
	Leersia virginica Willd.	white grass	infrequent	Native	LEVI2
	Melica nitens (Scribn.) Nutt. ex Piper	threeflower melic grass	infrequent	Native	MENI
	Microstegium vimineum (Trin.) A. Camus	Nepalese browntop	frequent	Introduced	MIVI
	Muhlenbergia sobolifera (Muhl. ex Willd.) Trin.	rock muhly	occasional	Native	MUSO
	Panicum anceps Michx.	beaked panicgrass	occasional	Native	PAAN
	Poa annua L.	annual bluegrass	occasional	Introduced	POAN
	Poa compressa L.	Canada bluegrass	occasional	Introduced	POCO
	Poa sylvestris A. Gray	woodland bluegrass	occasional	Native	POSY
	Schizachyrium scoparium (Michx.) Nash	little bluestem	frequent	Native	SCSC
	Setaria parviflora (Poir.) Kerguélen	marsh bristlegrass	occasional	Native	SEPA10
	Setaria pumila (Poir.) Roem. & Schult.	yellow foxtail	frequent	Native	SEPU8
	Sporobolus compositus (Poir.) Merr. var. *compositus*	composite dropseed	frequent	Native	SPCOC2
	Steinchisma hians (Elliot) Nash	gaping grass	occasional	Native	STHI
	Tridens flavus (L.) Hitchc.	purpletop tridens	frequent	Native	TRFL2

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	Vulpia octoflora (Walter) Rydb.	sixweeks fescue	frequent	Native	VUOC
Polemoniaceae	*Phlox divaricata* L.	wild blue phlox	frequent	Native	PHDI5
Polygonaceae	*Polygonum pensylvanicum* L.	Pennsylvania smartweed	occasional	Native	POPE2
	Polygonum persicaria L.	spotted ladysthumb	occasional	Native	POPE3
	Polygonum punctatum Elliot	dotted smartweed	occasional	Native	POPU5
	Polygonum scandens L.	climbing false buckwheat	occasional	Native	POSC3
	Polygonum virginianum L.	jumpseed	occasional	Native	POVI2
	Rumex crispus L.	curly dock	occasional	Native	RUCR
Polypodiaceae	*Pleopeltis polypodioides* (L.) Andrews & Windham	resurrection fern	occasional	Native	PLPO2
Portulaceae	*Claytonia virginica* L.	Virginia springbeauty	occasional	Native	CLVI3
Primulaceae	*Dodecatheon meadia* L.	pride of Ohio	infrequent	Native	DOME
Pteridaceae	*Adiantum aleuticum* (Rupr.) Paris	Aleutian maidenhair	occasional	Native	ADAL
	Adiantum pedatum L.	northern maidenhair	occasional	Native	ADPE
	Pellaea atropurpurea (L.) Link	purple cliffbreak	occasional	Native	PEAT2
Ranunculaceae	*Anemone virginiana* L.	tall thimbleweed	occasional	Native	ANVI3
	Aquilegia canadensis L.	red columbine	infrequent	Native	AQCA
	Clematis virginiana L.	devil's darning needles	infrequent	Native	CLVI5
	Delphinium carolinianum Walter	Carolina larkspur	infrequent	Native	DECA8
	Delphinium tricorne Michx.	dwarf larkspur	infrequent	Native	DETR
	Ranunculus fascicularis Muhl. ex Bigelow	early buttercup	occasional	Native	RAFA
	Ranunculus harveyi (A. Gray) Britton	Harvey's buttercup	occasional	Native	RAHA
	Ranunculus sardous Crantz	hairy buttercup	occasional	Introduced	RASA

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	Thalictrum thalictroides (L.) Eames & B. Boivin	rue anemone	occasional	Native	THTH2
Rhamnaceae	*Ceanothus americanus* L.	New Jersey tea	occasional	Native	CEAM
	Ceanothus herbaceus Raf.	Jersey tea	occasional	Native	CEHE
	Frangula caroliniana (Walter) A. Gray	Carolina buckthorn	occasional	Native	FRCA13
Rosaceae	*Crataegus crus-galli* L.	cockspur hawthorn	occasional	Native	CRCR2
	Fragaria virginiana Duchesne	Virginia strawberry	occasional	Native	FRVI
	Galium aparine L.	stickywilly	occasional	Native	GAAP2
	Geum canadense Jacq.	white avens	occasional	Native	GECA7
	Geum vernum (Raf.) Torr. & A. Gray	spring avens	occasional	Native	GEVE
	Gillenia stipulata (Muhl. ex Willd.) Baill.	American ipecac	occasional	Native	GIST5
	Potentilla recta L.	sulphur cinquefoil	occasional	Introduced	PORE5
	Prunus americana Marsh.	American plum	occasional	Native	PRAM
	Rosa carolina L.	Carolina rose	occasional	Native	ROCA4
	Rosa multiflora Thunb.	multiflora rose	occasional	Introduced	ROMU
	Rosa woodsii Lindl.	Wood's rose	rare	Native	ROWO
	Rubus aboriginum Rydb.	garden dewberry	occasional	Native	RUAB
	Rubus allegheniensis Porter	Allegheny blackberry	occasional	Native	RUAL
	Rubus occidentalis L.	black raspberry	occasional	Native	RUOC
Rubiaceae	*Cephalanthus occidentalis* L.	common buttonbush	infrequent	Native	CEOC2
	Diodia teres Walter	poorjoe	occasional	Native	DITE2
	Galium pilosum Aiton	hairy bedstraw	occasional	Native	GAPI2
	Houstonia caerulea L.	azure bluet	occasional	Native	HOCA4
	Houstonia ouachitana (E.B. Sm.) Terrell	Ouachita bluet	occasional	Native	HOOU

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Houstonia pusilla Schoepf	tiny bluet	occasional	Native	HOPU3
Salicaceae	*Populus deltoides* Bartram ex Marsh.	eastern cottonwood	frequent	Native	PODE3
	Salix caroliniana Michx.	coastal plains willow	occasional	Native	SACA5
Sapotaceae	*Sideroxylon lanuginosum* Michx. ssp. *lanuginosum*	gumbully	frequent	Native	SILAL3
Saxifragaceae	*Heuchera americana* L.	American alumroot	occasional	Native	HEAM6
	Saxifraga virginiensis Michx.	early saxifrage	occasional	Native	SAVI5
Scrophulariaceae	*Agalinis tenuifolia* (Vahl) Raf.	slenderleaf false foxglove	occasional	Native	AGTE3
	Aureolaria grandiflora (Benth.) Pennell	large yellow foxglove	occasional	Native	AUGR
	Mimulus alatus Aiton	sharpwing monkey flower	occasional	Native	MIAL2
	Pedicularis canadensis L.	Canadian lousewort	occasional	Native	PECA
	Penstemon tubiflorus Nutt.	white wand beardtongue	occasional	Native	PETU
	Scrophularia marilandica L.	carpenter's square	occasional	Native	SCMA2
	Verbascum thapsus L.	common mullien	infrequent	Introduced	VETH
	Veronica arvensis L.	corn speedwell	infrequent	Introduced	VEAR
Smilacaceae	*Smilax bona-nox* L.	saw greenbrier	occasional	Native	SMBO2
	Smilax herbacea L.	smooth carrionflower	occasional	Native	SMHE
	Smilax rotundiflora L.	roundleaf greenbrier	occasional	Native	SMRO
Solanaceae	*Physalis longifolia* Nutt.	longleaf groundcherry	infrequent	Native	PHLO4
	Physalis pubescens L.	husk tomato	infrequent	Native	PHPU7
	Solanum carolinense L.	Carolina horsenettle	infrequent	Native	SOCA3
	Solanum elaeagnifolium Cav.	silverleaf nightshade	infrequent	Native	SOEL
Staphyleaceae	*Staphylea trifolia* L.	American bladdernut	infrequent	Native	STTR

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
Tiliaceae	*Tilia americana* L.	American basswood	infrequent	Native	TIAM
Ulmaceae	*Celtis laevigata* Willd.	sugarberry	frequent	Native	CELA
	Celtis occidentalis L.	common hackberry	frequent	Native	CEOC
	Ulmus alata Michx.	winged elm	frequent	Native	ULAL
	Ulmus americana L.	American elm	frequent	Native	ULAM
	Ulmus rubra Muhl.	slippery elm	frequent	Native	ULRU
Urticaceae	*Urtica chamaedryoides* Pursh	heartleaf nettle	rare	Native	URCH3
Valerianaceae	*Valerianella radiata* (L.) Dufresne	beaked cornsalad	occasional	Native	VARA
Verbenaceae	*Callicarpa americana* L.	American beauty	occasional	Native	CAAM2
	Glandularia canadensis (L.) Nutt.	rose mock vervain	occasional	Native	GLCA2
	Phryma leptostachya L.	American lopseed	occasional	Native	PHLE5
	Verbena bonariensis L.	purpletop vervain	occasional	Introduced	VEBO
	Verbena stricta Vent.	hoary verbena	occasional	Native	VEST
	Verbena urticifolia L.	white vervain	occasional	Native	VEUR
Violaceae	*Viola bicolor* Pursh	field pansy	occasional	Native	VIBI
	Viola lanceolata L.	bog white violet	occasional	Native	VILA4
	Viola pedata L.	birdfoot violet	occasional	Native	VIPE
	Viola pubescens Aiton	downy yellow violet	occasional	Native	VIPU3
	Viola sagittata Aiton	arrowleaf violet	occasional	Native	VISA2
	Viola sororia Willd.	common blue violet	occasional	Native	VISO
	Viola triloba Schwein.	three lobed violet	occasional	Native	VITR2
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.	Virginia creeper	frequent	Native	PAQU2
	Vitis cinerea (Engelm.) Engelm. ex Millard	graybark grape	occasional	Native	VICI2

FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	U.S. NATIVITY	PLANTS SYMBOL
	Vitis mustangensis Buckley	mustang grape	rare	Native	VIMU2
	Vitis rotundifolia Michx.	muscadine	occasional	Native	VIRO3

CURRICULUM VITAE
MARY ELIZABETH GARD

Candidate for the Degree of
Master of Science

Thesis: TAXONOMIC AND ETHNOBOTANICAL INVESTIGATIONS OF THE VASCULAR FLORA OF OKLAHOMA

Major Field: Plant Sciences / Botany

Education:

Completed the requirements for the Master of Science in Botany at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Completed the requirements for the Bachelor of Science in Botany at Oklahoma State University. Stillwater, Oklahoma in May, 2005.

Experience:

Teaching Assistant
2003- present; Department of Botany / Oklahoma State University

2006; University of Oklahoma Biological Station, Lake Texoma, OK

Research Assistant
2006-2007; AGQUAPAL LAB, Oklahoma State University

2001; Algal Ecology Lab, Oklahoma State University

Assistant to the Curator
2001-2002; Herbarium, Oklahoma State University

Panel Member
2007-2009; Academic Integrity Panel / Oklahoma State University

Awards:

Arts and Sciences Outstanding Teaching Assistant, 2008
Graduate Student Teaching Assistant Scholarship, 2005-present
Arts and Sciences Outstanding Senior Award, 2004
Speairs Fellowship, 2002

Name: Mary Elizabeth Gard Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: Taxonomic and Ethnobotanical Investigations of the Vascular Flora of Oklahoma

Pages in Study: 122 Candidate for the Degree of Master of Science

Major Field: Botany

Between 2006 and the present, three taxonomic investigations of the flora of Oklahoma were conducted. Results of these studies are summarized in the following paragraphs.

In a two-year floristic inventory of the Eagle Pass, Sally Bull Hollow, and Workman Mountain tracts of the Ozark Plateau National Wildlife Refuge and the adjoining Ozark Plateau Wildlife Management Area, 442 species of vascular plants in 285 genera and 88 families were encountered. Ninety-two percent of the species were native and the largest families were Asteraceae, Fabaceae and Poaceae, together constituting 33% of the total taxa present in the three tracts. Eighty-five species collected were new records for Adair County. Nineteen species designated as rare by the Oklahoma Natural Heritage Inventory (OHNI) were encountered.

Preparation of a taxonomic treatment of the genus *Eragrostis* (Poaceae) for the *Flora of Oklahoma* revealed that 14 native and 6 introduced species of the genus are present in the state. Eighty vegetative, inflorescence, and spikelet features of each species were measured or scored. The range of variation for each character was determined and recorded. Descriptions of each species were written. Nomenclatural, taxonomic, and ecological notes were added as appropriate to complement the morphological descriptions. A dichotomous key to the 20 species was prepared.

An examination of the toxicity of six populations of *Tephrosia virginiana* (Fabaceae) in Oklahoma revealed all root extracts to exhibit 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. The variability among the replicates within sites produced few statistically significant differences among the six populations. Correlations between toxicity and edaphic factors were inconclusive.

Adviser's Approval: Ronald J. Tyrl_____