Analysis of remotely sensed data for the location of extant populations of *Platanthera praeclara* in northeastern Oklahoma: final report

Final Report, Projects E-44 and E-44

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Introduction

Platanthera praeclara is listed as a threatened species by the United States Fish and Wildlife Service. Likewise, ONHI ranks *P. praeclara* as a G2 (globally rare) S1 (state rare) species. Although historical records for *P. praeclara* exist from Craig and Rogers counties, there are no known extant populations in Oklahoma. *Platanthera praeclara* is a tallgrass prairie species that inhabits moist prairies and sedge meadows (Bender 1987).

In traditional field surveys, map and literature review are coupled with exhaustive field reconnaissance to locate extant populations of rare and endangered species. The ratio of new- populations-discovered to number-of-sites-visited is low using this methodology. Therefore, person-hours and funding may not be used optimally. Logistical difficulties encountered during fieldwork (i.e., landowner information, distance to potential sites) further decreases the efficiency of this methodology.

An effective means for locating high quality natural communities in large areas is satellite remote sensing (Colwell 1967, Griffiths et al. 1993). Indeed, digital data analysis has proven a useful tool for identifying rare species habitat in New England (Sperduto and Congalton 1996) and in the tallgrass prairie region (Lauver and Whistler 1993). The fact that all surfaces reflect characteristic spectral signatures is the premise for these analyses (Colwell 1967, Soriano and Paruelo 1992). The spectral signature of rare species habitat can be characterized by comparative analysis of digital satellite data and quantitative vegetation data from known locations of a rare species (Briggs and Nellis 1991). These data are then used in a regional classification of the satellite

data to produce a map of potential habitat, thus increasing the likelihood of successfully locating extant populations of rare species (Lauver and Whistler 1993). Also, a spatial database of tallgrass prairie remnants suitable for *P. praeclara* will aid any future reintroduction efforts.

Study Area

This study will combine field and satellite data in a effort to locate new populations of *P. praeclara* in 14 northeast Oklahoma counties (Adair, Cherokee, Craig, Delaware, Mayes, McIntosh, Muskogee, Nowata, Ottawa, Rogers, Sequoyah, Tulsa, Wagoner). This area includes all or part of six geomorphic provinces (Eastern Sandstone Cuesta Plains, Claremore Cuesta Plains, Neosho Lowlands, Ozark Plateau, Boston Mountains and Arkansas Hill and Valley Belt [Curtis and Ham 1972]). The geomorphological setting is formed by gently rolling lowlands, westward dipping cuestas, and the deeply dissected Ozark Plateau. Elevations range from 1,445 feet-above-sea-level on Mission Mountain in Cherokee County to 185 feet-above-sea-level on Coal Creek in Okmulgee County (Johnson 1972).

The surface geology of the study area is primarily sandstone, shale and limestone. Pennsylvanian sandstones dominate the surface geology in the western portion of the study area, with an increasing prevalence of limestone and sandstone in the east. The Ozark Plateau is composed of Mississippian limestones and chert. The Boston Mountains, south the Ozarks, is composed of sandstone (Branson and Johnson 1972). Five major rivers drain the study area; Arkansas, Caney, Deep Fork, Neosho,

and Verdigris Rivers. Floodplain geology of these streams is quaternary alluvium ranging from 25 - 100 feet in depth.

Potential vegetation in the study area is diverse. Much of the study area is covered by a diverse array of forest vegetation types. The predominant upland forest type are Post oak (*Quercus stellata*) - blackjack (*Q. marilandica*) - hickory (*Carya* spp.). Other forest vegetation types include oak (*Quercus* spp.)-hickory-pine (*Pinus echinata*) in the Ozark Plateau, white oak (*Q. alba - Carya alba - Tilia americana* forests, and chinkapin oak (*Q. muehlenbergii)* - sugar maple (*Acer saccharum*) forests (Bruner 1931, Blair 1938, Blair and Hubbell 1938, Duck and Fletcher 1945, Hoagland in press).

Tallgrass prairie vegetation is prevalent in the study area, particularly the Cherokee Prairie region (Bruner 1931, Blair 1938, Blair and Hubbell 1938, Duck and Fletcher 1945). Grassland communities dominated by big bluestem (*Andropogon gerardii)* - switchgrass (*Panicum virgatum*) and big bluestem - little bluestem (*Schizachyrium scoparium*) - Indiangrass (*Sorghastrum nutans*) are common. Glade vegetation, composed of side oats grama, are common in the Ozark plateau (Hoagland in press).

Methods

The study will employ protocols developed by the Oklahoma Natural Heritage Inventory (ONHI) for locating extant populations of *Platanthera praeclara* and high quality tallgrass prairie remnants using satellite data.

The project was executed in two phases over a two year period. Phase one involved the collection of quantitative data from historical localities for *P. praeclara* and high quality tallgrass prairie remnants. These data were used as training sites in order to execute a supervised classification of digital satellite data. High quality tallgrass prairie sites will be selected from Eyster-Smith (1984) and the ONHI database. Potential sites will be reconnoitered to determine whether they are still extant and whether they should be quantitatively sampled. The landowners of each site was determined and then contacted for access permission. Prior to quantitative sampling, each site was searched for extant populations of *P. praeclara* populations.

The field sampling design consisted of five 10M x10M plots arranged in a "cluster". A cluster consisted of a central plot, with an additional plot placed in each of the four cardinal directions 20m from the center plot. Every species present in the plot was recorded and cover (abundance) of each species for herbaceous plants and small shrubs is visually estimated in 5% increments (Barbour et. al 1987, Kent and Coker 1992).

Vegetation data were then compiled into a species-by-site matrix for multivariate analysis. Field data were analyzed using TWINSPAN (Hill 1979, Gauch 1982, Kent and Coker 1992) to identify grassland vegetation types. Species importance values were averaged for each TWINSPAN cluster in order to describe the vegetation types they represented. Field data from year one will be used to produce a supervised classification of Landsat TM imagery for northeastern Oklahoma. Nomenclature for plant species follows Kartesz 1994.

In year two, sites identified by the satellite image analysis as suitable *P. praeclara* habitat will be reconnoitered to determine whether populations of *P. praeclara* are present. Potential products from this study include: a classified satellite indicating the location of high quality tallgrass prairie remnants; an evaluation of the utility satellite imagery for locating new populations *P. praeclara*; quantitative vegetation for tallgrass prairie remnants; and surveys of potential *P. praeclara* sites.

Results and Discussion

Field data collection

Vegetation was sampled at a total of twenty sites (figure 1, table 1). Sixty-two landowners were contacted and permission requested to sample vegetation on their property, but only 20 consented. Sixteen responses were received, 14 of which granted access to property (Table 1). Permission was gained for access to six additional sites in the field. These sites were gathered from the ONHI database and Ester-Smith (1984).

A total of 183 species were encountered during quantitative sampling. *Platanthera praeclara* was not encountered at any site. The most frequently encountered species were *Andropogon gerardii* and *Schizachyrium scoparium*, which inhabited 19 of the 20 sample sites, and *Rudbeckia hirta* and *Sorghastrum nutans*, which were found at 18 sites. The highest mean cover values were scored by *A. gerardii* (36.3%) and *S. scoparium* (34.3). *Sorghastrum nutans* had a mean cover values of 13.1%. The mean cover value for *Panicum virgatum*, which was found at 16 sites, was 10.0%. *Rudbeckia hirta*, which was also a broadly distributed species, had a

mean cover value of only 4.2%. *Spiranthes cernua*, the only member of the orchid family encountered, was found at three sites. It had a mean cover value of 0.2%.

The highest species richness (n = 58) and species diversity score (H' = 3.689) was recorded at the Carter site in Muskogee County. This site also had an evenness score (E = 0.908) above the mean. The dominant grasses at the Carter site were *S. scoparium* (29%), *S. nutans* (14%), and *Panicum virgatum* (13%). The most abundant forbs were *Helianthus mollis* (17%) and *Pycnanthemum tenuifolia* (16%). Cover values for the remaining species were less than 10%.

The highest evenness score was recorded at the Jeter site in Washington County (E = 0.904), but a species richness of 37 and diversity score of 3.26. Dominant grasses at this site were *A. gerardii* (25%), *S. nutans* (21%), and *Sporobolus asper* (23%). *Elymus canadensis* (17%) and *P. virgatum* (13%) were subordinate grasses. The remaining 32 species had cover values less than 10%.

The lowest richness was recorded at the Hall site in Wagoner county (n = 23), which also had a below average species diversity score (H' = 2.66) and an above average evenness score (E = 0.849). The dominant grasses were *S. nutans* (22%), *Paspalum setaceum* (21%), *S. scoparium* (19%), *A. gerardii* (17%), and *P. virgatum* (11%). The remaining 18 species had cover values between 1% and 8%.

The lowest evenness score (E = 0.716) and below average diversity score (H' = 2.88), but second highest species richness (n = 56) was at the Easley site in Ottawa County. Cover values were strongly dominated by *A. gerardii* (66.4%) and *S. scoparium* (32.8%). The remaining 54 species had cover values for between 0.2% and

6%. Copan Wildlife Management Area had the lowest species diversity score (n = 2.478), the second lowest species richness (n = 27) and a below average evenness score (E = 0.75). *Andropogon gerardii* had the highest cover value at this site (70%). Species with cover values of 10% or greater were *P. virgatum* (14%), *S. scoparium* (22%), and *S. asper* (10%). The remaining 24 species had cover values between 1% and 6%.

Analysis of remotely sensed data

We were unable to discern native hay meadows from converted pastures and other landscape elements in the analysis of the 1992 Landsat TM image available for this study. The image was analyzed using a Normalized Difference Vegetation Index, which is affective in discriminating most vegetation types. Two factors might account for the ineffectiveness of this analysis. Satellite imagery has to be collected at a point during the growing season when vegetation types of interest are at peak biomass. For example, winter, or leaf off, imagery is best for detecting vegetation types dominated by coniferous or evergreen vegetation. The Landsat TM image that was available for this analysis was date 1 October 1992. This is well past the time of year when both fescue pastures and native hay meadows are cut for hay. A more effective approach would apply a multi-temporal approach, that is to say, acquiring imagery from two periods within the growing season. It is recommended that images by acquired for, just prior to fescue cutting and another from late June, just prior to the cutting of native hay.

The highly fragmented landscape in which prairie remnants and native hay meadows in northeastern Oklahoma presented another difficulty in developing an accurate map of the region. Fescue (*Festuca arundinacea*, an exotic species) dominated pastures are intermingled with native hay meadows and pastures of native grasses degraded by overgrazing and the application of herbicide to reduce forb abundance. Urban encroachment in the vicinity of Tulsa and Bartlesville has also had an adverse impact on native grasslands.

Field season 1998

100 potential prairie hay meadow sites were visited in the 1998 field season. Sites were reconnoitered for *P. praeclara* if they met the following criteria:

1) Not heavily grazed, as evidenced by trampling and vegetation cropped to less than 3 cm.
2) The dominant grasses were native (i.e., *A. gerardii, S. scoparium, S. nutans,* and/or *P. virgatum*). Pastures which had been converted to exotic pasture grasses (i.e., *Festuca arundinacea, Bothriochloa ischaemum*) were excluded from consideration.
4) Presence of “conservative” (i.e., decreaser) plant species such as *Amorpha canescens, Helianthus mollis, Eryngium yuccifolium,* and/or *Silphium laciniatum*.
3) Currently or recently in row crop production.
4) No evidence of extensive physical modification.

Sites meeting these criteria were then reconnoitered for *Platanthera praeclara* and evaluated using the ONHI Site Survey and Community Reconnaissance forms (Appendix 1). These are standard forms employed by ONHI biologists for entry of site specific information into the main ONHI database and to evaluate the conservation value of the sites. The ONHI Community Reconnaissance form evaluates a site based upon four criteria. The first is site quality, which considers the unique biological features, maturity of the site, and how representative the site is of a particular vegetation type. The second factor is site condition, which evaluates disturbances on site and the presence of exotic species. A key factor influencing the persistence of prairie hay meadows is annual cutting for hay, which typically takes place around July 4. This practice simulates natural disturbance such as grazing and fire which have been removed from the system. In fact, landowners will burn sites from time-to-time to stimulate grass production. The third factor site viability. The biologist is asked to determine the likelihood that a site will persist in its current condition. The immediate threat to a hay meadow site is conversion to non-native grasses or row crop production. The fourth criteria is site defensibility, in other words, can the area be protected from extrinsic factors if conservation action was warranted. Each of these criteria are scored on a scale of A-D. "A" represents the best possible situation and "D" the worst. A composite A-D score then made.

Of the sites visited, 56 meet the criteria listed above. *Platathera praeclara* was not encountered at an of these sites. The only member of the orchid family encountered was *Spiranthes cernuua*. These sites were than evaluated using ONHI

site ranking criteria. Site ranking were high, ranging from A -C (A = 9, B = 38, C = 9). Sites ranged in size from 25 to 200 acres. The landscape in which these hay meadows reside is highly fragmented. Adjacent land uses are often incompatible with prairie hay meadows. In most cases, the adjacent land use is either heavily grazed pastures of native grass (particularly in Washington County) or pastures that have been converted to *F. arundinacea* or *B. ischmaemum*. East of Vinita, some hay meadows are being lost to strip mining for coal. Indeed, abandoned strip mines can be found in Rogers, Nowata, Craig, and Washington counties. Although there is no direct evidence that native hay meadows were at these sites, it is likely that some were present.

Conclusions

Extensive potential habitat for *P. praeclara* exists throughout northeast Oklahoma. In this study we visited 76 sites (20 quantitatively sampled in year one and 56 reconnoitered in year two). *Platanthera praeclara* was not found at any of these sites. The use of satellite imagery, or digital imagery gathered from aerial platforms, has the potential to focus the field effort of botanists. In this study, we analyzed a Landsat TM image from 1 October 1992 available through the Oklahoma Biological Survey (funds available for this project were insufficient for the purchase of a current or multiple images). Analysis of this image was not successful in locating prairie hay meadow sites. The October image was unable to discriminate native hay meadows and pasture of exotic grasses. This was attributed not only to the image date, but also the low number of quantitatively sampled training sites (n = 20). Although approximately

sixty land owners were contacted, only twenty granted access to their property. The use of digital imagery should not be discarded. The use of multi-temporal data, such as an image from May, prior to the cutting of fescue pastures, and another from late June, prior to the cutting of native hay meadows, would help tremendously in resolving the location of native hay meadows. This technique has been successfully used in other states to locate habitat for rare species (Lauver and Whistler 1993).

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Table 1: Ownership and location information for quantitatively sampled hay meadow sites.

Landowner	Address	County	Legal Descrip.
Beeson, Floyd L.	Rt. 2. Box 1517, Ramona, OK, 74061	Washington	T23N, R13E, sec. 11
Copan Wildlife Management Area	Oklahoma Department of WIldlife Conservation, OKC, OK	Washington	T28N, R13E, sec. 6
Delozier, Crummie	Rt. 3 Box 160, Chelsea, OK 74016	Nowata	T26N, R14E, sec. 26
Easley, Charles E.	C/O Ted Easley, Joplin, MO 64804	Ottawa	T29N, R22E, sec. 23
Flusche, Vincent H.	4701 S. 104th St. W., Muskogee, OK 74401	Muskogee	T14N, R17E, sec. 21
Forrest, William J.	13321 N. Meridian, Suite 314, OKC, OK 73120	Delaware	T25N, R24E, sec. 32
Goodwin, S.D.	56801 E. 160 Rd., Fairland, OK 74343	Ottawa	T27N, R23E, sec. 32
Huerter, Charles	1409 SE Prairie Hts. Dr., Bartlesville, OK 74006	Nowata	T26N, R14E, sec. 23
Jeter, Joe	Rt. 1 Box 112, Copan, OK 74022	Washington	T29N, R13E, sec. 26
Keys, Clun D.	Rt. 1 Box 418, Vinita, OK 74301	Craig	T25N, R19E, sec. 1
Kyler, Delbert	P.O. Box 117, Pawhuska, OK 74056	Osage	T24N, R8E, sec. 4
Moore, Bernadine	Rt. 2 Box 418, Inola, OK 74036	Rogers	T20N, R17E, sec. 11
Sooner Land & Livestock	P.O. Box 638, Pawhuska, OK 74056	Osage	T29N, R7E, sec. 33
Stambaugh, John	9 E. 4th St. Suite 700, Tulsa, OK 74013	Tulsa	T19N, R14E, sec. 27
Stutzman, Bob	705 Merritt Ct., Naperville, IL 60540	Mayes	T22N, R19E, sec. 11
Tallgrass Prairie Preserve	The Nature Conservancy, Oklahoma Field Office, Tulsa, OK	Osage	T28N, R8E, sec. 36

Table 2: Average species cover values for twenty quantitatively sampled hay meadow site in northeastern Oklahoma.

SPECIES	Jeter	Hall	Delzoier	Huerter	Stambaugh	Keys
Acer saccharum	0	0	0	0	0	0
Achillea millifolium	4	0	5	4	0	0
Agrostis hyemalis	0	0	3	0	0	0
Amaranthus sp.	0	0	0	0	0	0
Ambrosia artemisifolia	4	1	0	6	3	0
Ambrosia bidentata	0	0	0	0	0	0
Amorpha canascens	0	0	0	0	5	0
Amoselinum popei	5	0	0	1	0	0
Andropogon gerardii	25	17	15	32	38	39
Antennaria plantaginifolia	0	0	0	0	5	0
Apocynum cannabium	0	0	0	0	0	0
Aristida purpurea	0	0	6	0	0	0
Arnoglossum plantagineum	0	0	0	0	0	0
Artemisia ludoviciana	0	0	0	0	0	0
Asclepias incarnata	0	0	0	0	0	0
Asclepias sp	0	0	0	0	5	2
Asclepias stenophylla	0	0	0	0	0	1
Asclepias tuberosa	0	0	0	0	0	0
Asclepias verticillata	0	1	0	0	0	0
Asclepias viridiflora	5	0	5	4	0	0
Asclepias viridis	0	0	0	0	0	0
Astranthium integrifolium	0	0	0	0	0	0
Baptisia alba	0	0	0	0	9	3
Baptisia australis	0	0	0	0	0	0
Baptisia bracteata	0	0	0	4	0	0
Bothriochloa saccharoides	0	0	1	0	0	0
Bouteloua curtipendula	0	0	6	0	5	0
Bromus japonicus	0	3	16	2	0	0
Buchnera americana	0	0	0	0	0	0
Calopogon oklahomensis	0	0	0	0	0	0
Calylophus hartweggii	0	0	0	0	0	0
Carduus nutans	0	0	1	3	0	0
Carex crawei	0	0	0	0	0	52
Carex meadii	6	0	3	6	0	0
Castelleja indivisa	0	0	0	0	0	0
Ceanothus americanus	0	0	0	0	0	0

SPECIES	Jeter	Hall	Delzoier	Huerter	Stambaugh	Keys
Cerastium brachypodium	0	0	4	1	0	0
Chamaecrista fasiculata	5	0	0	0	0	0
Cirsium altissimum	0	0	0	0	0	0
Cirsium undulatum	0	0	0	0	1	0
Coelorachis cylindrica	0	0	0	0	0	0
Collinsia violacea	0	0	0	0	2	0
Conyza canadensis	0	0	1	0	0	0
Coreopsis grandiflora	0	0	0	0	0	0
Coreopsis palmata	0	0	0	0	0	0
Coreopsis tinctoria	0	2	0	4	5	5
Croton capitatus	0	0	2	0	0	0
Cynodon dactylon	5	0	0	0	0	0
Cyperus ovularis	4	0	0	0	0	0
Cyperus setigerus	0	1	4	0	0	0
Dalea candida	0	0	0	0	4	0
Dalea purpurea	1	0	0	5	4	0
Desmodium illinoense	0	1	0	0	0	0
Desmodium sessilifolium	4	0	0	0	0	0
Dianthus ameria	0	2	0	0	0	0
Dichanthelium acuminatum	5	0	4	4	0	0
Dichanthelium oligosanthes	0	0	0	0	0	0
Dichanthelium sphaerocarpon	0	0	0	0	0	0
Diospyros virginica	3	0	0	0	0	0
Echinacea pallida	0	0	0	0	3	7
Elymus canadensis	17	0	0	0	0	0
Elymus virginica	0	0	10	2	0	0
Eragrostis sp.	5	0	0	10	0	0
Eragrostis spectabilis	0	0	0	0	0	0
Eragrostis trichodes	0	0	0	0	0	0
Erigeron annuus	0	0	0	0	0	0
Erigeron strigosus	0	5	0	0	0	5
Eryngium yuccifolium	0	0	0	4	0	2
Eupatorium serotinum	6	0	0	0	0	0
Euphorbia corolata	0	0	0	1	0	0
Euphorbia hexagonoptea	0	0	1	0	0	0
Festuca arundinacea	5	1	3	3	0	0
Fimbristilis puberula	0	0	0	0	0	0
Fiurena simplex	0	0	0	0	0	0
Gaillardia pulchella	0	0	0	0	0	0

SPECIES	Jeter	Hall	Delzoier	Huerter	Stambaugh	Keys
Grindelia squarrosa	0	0	0	0	0	0
Hedeoma hispidum	0	0	0	0	0	0
Helenium amarum	0	0	0	0	0	0
Helenium flexuosum	0	0	0	0	0	0
Helianthus annuus	0	0	0	0	0	0
Helianthus mollis	0	0	0	6	6	0
Hieracium longipilum	0	0	0	0	0	0
Hordeum pusillum	0	0	4	0	0	0
Juncus interior	3	0	6	1	0	0
Juncus marginatus	0	0	0	0	0	0
Juncus scirpoides	0	0	0	0	5	0
Juniperus virginiana	0	0	0	0	0	0
Koeleria cristata	2	0	0	0	2	0
Krigia caespitosa	0	0	1	0	0	0
Lepidium campestre	1	0	0	0	0	0
Lespedeza capitata	0	0	0	0	0	0
Lespedeza cuneata	0	8	5	0	0	0
Lespedeza stipulasia	5	0	5	5	0	5
Lespedeza violacea	0	0	0	0	0	0
Lespedeza virginica	3	0	0	1	5	0
Liatris aspera	0	0	0	0	0	0
Liatris pychnostachya	0	0	0	0	0	6
Linum rigidum	0	0	2	3	5	0
Lithospermum incisum	0	0	0	0	3	0
Lobelia spicata	0	0	0	5	5	4
Lollium perenne	0	0	1	0	0	0
Ludwigia alternifolia	0	0	0	0	0	0
Medicago lupulina	0	0	0	0	0	0
Melilotus officinale	0	0	1	0	0	0
Mentzelia oligosperma	0	0	0	0	5	0
Mimosa nuttalli	0	0	0	5	4	5
Mirabilis nyctaginea	0	0	0	0	0	0
Monarda clinopodoides	0	0	0	0	0	0
Monarda fistulosa	0	0	0	0	0	0
Oxalis stricta	5	0	1	5	1	4
Oxalis violacea	0	0	2	0	0	1
Panicum anceps	0	4	0	0	0	0
Panicum microcarpon	0	0	0	0	0	0
Panicum oligosanthes v.	6	0	6	10	9	10

SPECIES	Jeter	Hall	Delzoier	Huerter	Stambaugh	Keys
Panicum virgatum	13	11	0	0	0	9
Paspalum floridanum	0	0	1	8	0	0
Paspalum setaceum	0	21	0	8	4	0
Penstemon tubaeflorus	0	0	0	1	0	0
Phalaris caroliniana	0	3	4	0	0	0
Phlox pilosa	0	0	0	0	4	0
Physostegia angustifolia	0	0	0	0	0	2
Plantago aristata	0	0	5	4	0	0
Plantago virginica	2	0	0	0	0	0
Poa pratensis	4	0	7	0	0	4
Polygala incarnata	0	0	0	2	4	0
Polygala sanguinea	0	0	0	1	5	5
Polytaenia nuttallii	0	0	0	2	0	0
Potentilla recta	0	0	0	0	0	0
Potentilla simplex	0	0	0	0	0	0
Prunella vulgaris	0	0	0	1	0	0
Pseudognaphalium obtusifolium	1	0	0	2	0	4
Psoralidium tenuiflorum	0	0	0	5	4	0
Ptilimnium capillaceum	0	0	0	0	0	5
Pycnanthemum tenuifolium	0	0	0	0	0	0
Pyrropappus carolinianus	0	0	1	0	0	0
Rhus copallina	0	0	0	0	0	0
Rhynchospora globularis	0	0	0	0	0	0
Rosa multiflora	0	0	0	0	5	0
Rosa setigera	0	0	0	0	0	0
Rubus allegheniensis	0	0	0	0	0	19
Rubus sp.	4	0	0	0	0	0
Rubus trivialis	0	0	0	2	0	0
Rudbeckia grandiflora	0	0	0	0	0	5
Rudbeckia hirta	2	6	5	5	5	5
Ruellia humilis	0	0	0	4	5	5
Rumex crispus	4	0	2	0	0	0
Sabatia angularis	0	0	1	0	0	0
Sabatia campestre	0	0	0	1	0	0
Salvia azurea	0	0	0	0	0	0
Sassafrass albidum	0	0	0	0	0	0
Schizachirium scoparium	9	19	16	40	62	39
Scirpus pendulus	0	0	0	0	0	0
Scirpus sp.	0	0	0	0	0	0

SPECIES	Jeter	Hall	Delzoier	Huerter	Stambaugh	Keys
Scleria pauciflora	1	0	0	5	0	0
Scutellaria resinosa	0	0	0	2	0	0
Setaria geniculata	6	8	0	3	0	0
Silphium laciniatum	0	0	0	0	0	0
Solanum carolinense	2	0	0	0	0	0
Solanum dimidatum	0	0	2	0	0	0
Solidago missouriensis	0	0	0	0	5	2
Solidago rigida	0	3	0	0	0	0
Sonchus asper	0	0	0	0	0	0
Sorghastrum nutans	21	22	14	17	13	0
Spiranthes cernua	0	0	0	0	0	0
Sporobolus asper	23	0	46	5	10	0
Stillingia sylvatica	0	0	0	5	0	0
Strophostyles leiosperma	0	0	0	0	0	0
Stylosanthes biflora	0	0	0	0	0	0
Symphoricarpos orbiculatus	0	0	3	1	0	0
Symphyotrichum ericoides	0	0	0	5	0	0
Symphyotrichum patens	0	1	8	0	5	2
Taraxacum officinale	0	0	0	0	0	0
Tephrosia virginica	0	0	0	0	0	0
Tragia betonicifolia	0	0	0	1	0	0
Tragia urticifolia	0	0	0	0	0	0
Trifolium dubium	0	1	0	0	0	0
Triodanis perfoliata	0	0	2	0	0	0
Tripsicum dactyloides	0	0	0	0	0	0
Valerainella radiata	0	0	5	2	0	0
Vernonia baldwinii	0	9	1	0	0	0
Vernonia fasciculata	0	0	0	0	0	0
Viola sp	0	0	0	0	0	0
Vulpia octoflora	0	0	0	2	0	0

Table 2: continued

SPECIES	Moore	Morrow	McGowen	Forrest	Pryor	Easley
Acer saccharum	0	1	0	0	0	0
Achillea millifolium	5	0	0	0	5	1
Agrostis hyemalis	0	0	0	0	0	0
Amaranthus sp.	0	0	0	0	0	0
Ambrosia artemisifolia	0	5	0	3	5	1
Ambrosia bidentata	0	0	0	0	0	0
Amorpha canascens	0	1	0	0	3	0.6
Amoselinum popei	0	0	0	0	0	0
Andropogon gerardii	56	66	66	0	12	66.4
Antennaria plantaginifolia	4	3	3	1	2	0.4
Apocynum cannabium	0	0	0	0	0	0
Aristida purpurea	0	0	0	7	0	0
Arnoglossum plantagineum	5	0	1	0	0	0
Artemisia ludoviciana	0	0	0	0	0	0
Asclepias incarnata	0	0	0	0	0	0
Asclepias sp	4	5	5	0	0	0
Asclepias stenophylla	0	1	0	0	0	4
Asclepias tuberosa	0	0	0	0	0	0
Asclepias verticillata	0	0	0	0	0	0
Asclepias viridiflora	0	0	0	0	0	0
Asclepias viridis	0	0	0	1	5	1
Astranthium integrifolium	0	0	0	0	0	0
Baptisia alba	1	4	0	0	5	1
Baptisia australis	1	0	1	0	1	0.2
Baptisia bracteata	0	0	0	0	0	0
Bothriochloa saccharoides	0	0	0	0	0	0
Bouteloua curtipendula	0	0	0	0	0	0
Bromus japonicus	3	0	0	0	5	4
Buchnera americana	1	2	5	0	0	0
Calopogon oklahomensis	0	0	0	0	0	0
Calylophus hartweggii	0	0	0	0	0	0
Carduus nutans	0	0	0	0	0	0
Carex crawei	7	0	0	2	0	3
Carex meadii	0	0	0	0	0	0
Castelleja indivisa	0	1	0	0	0	0
Ceanothus americanus	0	0	0	0	0	0
Cerastium brachypodium	0	0	0	0	0	0

SPECIES	Moore	Morrow	McGowen	Forrest	Pryor	Easley
Chamaecrista fasiculata	0	0	0	0	0	0
Cirsium altissimum	0	0	0	0	0	0
Cirsium undulatum	0	1	1	0	1	0.2
Coelorachis cylindrica	3	22	0	0	0	0
Collinsia violacea	0	0	0	0	1	0.2
Conyza canadensis	0	0	0	0	0	0
Coreopsis grandiflora	0	0	0	0	5	1
Coreopsis palmata	0	0	0	0	1	0.2
Coreopsis tinctoria	8	7	5	0	2	3.4
Croton capitatus	0	0	0	0	0	0
Cynodon dactylon	0	0	0	5	0	0
Cyperus ovularis	0	0	0	2	0	0
Cyperus setigerus	0	0	0	0	0	0
Dalea candida	0	0	0	0	0	0
Dalea purpurea	0	0	0	0	5	1
Desmodium illinoense	0	0	0	0	0	0
Desmodium sessilifolium	0	0	0	0	0	0
Dianthus ameria	0	0	0	0	0	0
Dichanthelium acuminatum	0	0	0	0	0	0
Dichanthelium oligosanthes	0	0	2	1	0	0
Dichanthelium sphaerocarpon	0	0	0	0	0	0
Diospyros virginica	0	0	0	0	0	0
Echinacea pallida	0	0	0	0	0	0
Elymus canadensis	0	0	0	0	0	0
Elymus virginica	0	0	0	0	5	6
Eragrostis sp.	6	0	0	8	0	0
Eragrostis spectabilis	0	0	0	0	0	0
Eragrostis trichodes	0	0	0	2	0	5
Erigeron annuus	0	0	0	0	0	0
Erigeron strigosus	4	6	5	5	5	1
Eryngium yuccifolium	1	1	5	0	5	4
Eupatorium serotinum	0	0	0	0	0	0
Euphorbia corolata	0	0	0	5	0	1
Euphorbia hexagonoptea	0	0	0	0	0	0
Festuca arundinacea	3	1	1	3	5	2
Fimbristilis puberula	0	7	9	0	0	0
Fiurena simplex	0	0	0	0	0	0
Gaillardia pulchella	0	0	0	0	0	0
Grindelia squarrosa	0	0	0	0	0	0

SPECIES	Moore	Morrow	McGowen	Forrest	Pryor	Easley
Hedeoma hispidum	0	0	0	4	0	0
Helenium amarum	0	0	0	0	0	0
Helenium flexuosum	0	0	0	0	0	0
Helianthus annuus	0	0	0	0	0	0
Helianthus mollis	0	3	0	0	1	1.2
Hieracium longipilum	0	0	0	0	0	0
Hordeum pusillum	3	0	0	0	0	0
Juncus interior	0	0	0	5	0	0
Juncus marginatus	4	0	0	0	4	4.8
Juncus scirpoides	7	3	0	2	0	4
Juniperus virginiana	0	0	0	1	0	0
Koeleria cristata	0	0	3	0	3	1.6
Krigia caespitosa	0	0	0	1	0	0
Lepidium campestre	0	0	0	0	0	0
Lespedeza capitata	0	0	0	0	0	0
Lespedeza cuneata	0	0	0	37	0	0
Lespedeza stipulasia	5	4	1	5	5	1
Lespedeza violacea	0	0	0	0	0	0
Lespedeza virginica	0	0	1	1	0	0
Liatris aspera	0	0	0	0	0	0
Liatris pychnostachya	0	0	0	0	0	2
Linum rigidum	0	3	2	0	0	0
Lithospermum incisum	0	0	0	0	0	0
Lobelia spicata	4	5	4	0	1	0.2
Lollium perenne	0	0	0	0	0	0
Ludwigia alternifolia	0	0	0	0	0	0
Medicago lupulina	0	0	0	0	0	0
Melilotus officinale	0	0	0	0	0	0
Mentzelia oligosperma	0	0	0	0	0	0
Mimosa nuttalli	1	8	0	0	4	1.8
Mirabilis nyctaginea	0	0	0	0	0	0
Monarda clinopodoides	0	0	0	0	0	0
Monarda fistulosa	0	0	0	0	0	0
Oxalis stricta	3	4	5	1	0	1
Oxalis violacea	0	0	0	0	0	1
Panicum anceps	0	0	0	0	0	0
Panicum microcarpon	0	0	0	9	0	1
Panicum oligosanthes v.	10	9	9	0	5	1
Panicum virgatum	4	6	20	0	7	1.4

SPECIES	Moore	Morrow	McGowen	Forrest	Pryor	Easley
Paspalum floridanum	0	0	0	0	0	0
Paspalum setaceum	5	3	5	3	3	0.6
Penstemon tubaeflorus	0	1	0	0	1	0.2
Phalaris caroliniana	0	0	0	0	0	0
Phlox pilosa	0	0	0	0	0	0
Physostegia angustifolia	4	0	2	0	5	5
Plantago aristata	2	4	2	11	0	0
Plantago virginica	0	4	5	1	0	0
Poa pratensis	0	0	2	0	0	0
Polygala incarnata	1	5	0	0	0	0
Polygala sanguinea	5	0	1	1	0	3
Polytaenia nuttallii	0	0	0	0	3	2.6
Potentilla recta	0	1	0	0	0	0
Potentilla simplex	0	0	0	0	0	0
Prunella vulgaris	0	0	0	0	0	0
Pseudognaphalium obtusifolium	1	2	3	3	0	0
Psoralidium tenuiflorum	0	1	0	0	0	0
Ptilimnium capillaceum	0	7	3	0	0	4
Pycnanthemum tenuifolium	4	0	0	0	1	4.2
Pyrropappus carolinianus	0	0	0	0	0	0
Rhus copallina	0	0	0	0	0	0
Rhynchospora globularis	0	0	3	0	0	0
Rosa multiflora	0	0	0	0	0	0
Rosa setigera	0	0	0	1	0	0
Rubus allegheniensis	0	0	0	0	0	0
Rubus sp.	0	0	0	0	0	0
Rubus trivialis	0	0	0	0	0	0
Rudbeckia grandiflora	0	1	0	0	0	0
Rudbeckia hirta	5	5	5	6	5	1
Ruellia humilis	5	5	0	0	4	2.8
Rumex crispus	0	0	0	0	0	0
Sabatia angularis	0	0	0	0	0	0
Sabatia campestre	1	3	0	1	0	0
Salvia azurea	0	0	0	0	0	0
Sassafrass albidum	0	0	0	0	0	0
Schizachirium scoparium	45	42	52	0	73	32.6
Scirpus pendulus	0	0	0	0	0	0
Scirpus sp.	0	0	0	0	0	1
Scleria pauciflora	0	0	0	0	0	0

SPECIES	Moore	Morrow	McGowen	Forrest	Pryor	Easley
Scutellaria resinosa	0	0	0	0	0	0
Setaria geniculata	5	20	0	0	0	0
Silphium laciniatum	0	0	0	0	1	0.2
Solanum carolinense	1	0	0	1	0	0
Solanum dimidatum	0	0	0	0	0	0
Solidago missouriensis	1	3	2	2	3	0.6
Solidago rigida	0	0	0	0	0	0
Sonchus asper	0	0	0	0	0	0
Sorghastrum nutans	14	26	30	0	10	9
Spiranthes cernua	0	0	0	3	1	0.2
Sporobolus asper	0	7	34	0	6	2.2
Stillingia sylvatica	0	0	0	0	0	0
Strophostyles leiosperma	0	0	0	0	0	0
Stylosanthes biflora	0	0	1	0	0	4
Symphoricarpos orbiculatus	0	0	0	0	0	0
Symphyotrichum ericoides	0	0	0	0	0	0
Symphyotrichum patens	0	1	0	4	4	0.8
Taraxacum officinale	0	0	1	0	0	0
Tephrosia virginica	0	0	0	0	1	0.2
Tragia betonicifolia	0	0	0	0	0	0
Tragia urticifolia	0	0	0	0	0	0
Trifolium dubium	0	0	0	0	0	0
Triodanis perfoliata	0	0	3	0	0	0
Tripsicum dactyloides	0	0	0	0	0	0
Valerainella radiata	0	0	0	0	0	0
Vernonia baldwinii	0	0	0	0	0	0
Vernonia fasciculata	0	0	0	0	0	0
Viola sp	0	0	0	0	0	4
Vulpia octoflora	0	0	0	0	0	0

Table 2: continued

SPECIES	Carter	Flushe	White oak	Copan	Wattenb	TGPP
Acer saccharum	0	0	0	0	0	0
Achillea millifolium	0	2	0	3	0	2
Agrostis hyemalis	0	0	0	0	0	0
Amaranthus sp.	0	0	0	0	0	1
Ambrosia artemisifolia	0	0	0	5	0	9
Ambrosia bidentata	0	0	0	0	0	0
Amorpha canascens	4	4	3	0	4	4
Amoselinum popei	0	0	0	0	0	0
Andropogon gerardii	6	5	44	70	52	49
Antennaria plantaginifolia	3	0	5	0	0	0
Apocynum cannabium	0	0	0	0	0	0
Aristida purpurea	5	0	1	0	2	0
Arnoglossum plantagineum	0	0	0	0	0	0
Artemisia ludoviciana	0	0	0	0	0	10
Asclepias incarnata	0	0	0	0	0	1
Asclepias sp	1	0	2	0	0	0
Asclepias stenophylla	0	5	0	0	2	0
Asclepias tuberosa	0	0	0	0	0	0
Asclepias verticillata	0	0	1	0	0	0
Asclepias viridiflora	0	0	0	0	0	0
Asclepias viridis	0	3	4	0	4	4
Astranthium integrifolium	0	3	0	0	0	0
Baptisia alba	4	0	4	3	0	2
Baptisia australis	0	0	0	0	0	0
Baptisia bracteata	0	5	0	0	0	0
Bothriochloa saccharoides	0	0	0	0	0	0
Bouteloua curtipendula	3	3	2	0	6	6
Bromus japonicus	0	0	0	0	0	0
Buchnera americana	0	0	4	0	0	0
Calopogon oklahomensis	1	0	0	0	0	0
Calylophus hartweggii	1	0	0	0	0	0
Carduus nutans	0	0	0	0	0	0
Carex crawei	0	0	5	0	0	0
Carex meadii	0	0	0	0	0	0
Castelleja indivisa	1	5	0	0	0	0
Ceanothus americanus	0	0	0	0	0	0
Cerastium brachypodium	0	0	0	0	0	0

SPECIES	Carter	Flushe	White oak	Copan	Wattenb	TGPP
Chamaecrista fasiculata	0	0	0	0	0	1
Cirsium altissimum	0	0	0	0	0	12
Cirsium undulatum	1	0	0	0	0	0
Coelorachis cylindrica	7	6.2	0	0	0	0
Collinsia violacea	0	5	0	0	0	0
Conyza canadensis	0	0	0	0	0	0
Coreopsis grandiflora	4	3	5	0	0	0
Coreopsis palmata	2	0	0	0	0	0
Coreopsis tinctoria	0	0	0	0	4	0
Croton capitatus	0	0	0	0	0	0
Cynodon dactylon	0	0	0	0	0	0
Cyperus ovularis	3	1	0	5	1	0
Cyperus setigerus	0	0	0	0	0	0
Dalea candida	0	0	1	0	0	0
Dalea purpurea	2	1	0	0	2	0
Desmodium illinoense	0	0	0	0	3	3
Desmodium sessilifolium	0	0	0	0	0	0
Dianthus ameria	0	0	0	0	0	0
Dichanthelium acuminatum	0	1	0	0	0	0
Dichanthelium oligosanthes	0	0	0	0	0	0
Dichanthelium sphaerocarpon	1	0	0	0	0	0
Diospyros virginica	2	0	0	0	0	0
Echinacea pallida	0	0	0	0	0	0
Elymus canadensis	0	0	0	0	0	0
Elymus virginica	0	0	0	6	0	5
Eragrostis sp.	0	1	0	0	0	0
Eragrostis spectabilis	0	0	0	0	0	0
Eragrostis trichodes	0	0	0	0	0	0
Erigeron annuus	0	0	5	0	0	0
Erigeron strigosus	5	3	5	4	3	0
Eryngium yuccifolium	4	0	3	0	0	0
Eupatorium serotinum	0	0	0	0	0	0
Euphorbia corolata	2	2	2	0	2	1
Euphorbia hexagonoptea	0	0	0	0	0	0
Festuca arundinacea	0	0	1	0	0	0
Fimbristilis puberula	0	0	0	0	0	0
Fiurena simplex	0	0	0	0	0	0
Gaillardia pulchella	3	5	0	0	0	0
Grindelia squarrosa	0	0	0	0	0	2

SPECIES	Carter	Flushe	White oak	Copan	Wattenb	TGPP
Hedeoma hispidum	0	0	0	0	0	0
Helenium amarum	0	0	0	0	1	0
Helenium flexuosum	0	0	1	0	0	0
Helianthus annuus	0	0	0	1	0	0
Helianthus mollis	17	1	5	0	0	0
Hieracium longipilum	1	3	1	0	1	0
Hordeum pusillum	0	0	0	0	0	0
Juncus interior	0	0	0	0	0	0
Juncus marginatus	4	0	2	0	0	0
Juncus scirpoides	0	0	1	0	0	0
Juniperus virginiana	0	0	0	0	0	0
Koeleria cristata	0	0	2	0	4	0
Krigia caespitosa	0	0	0	0	0	0
Lepidium campestre	0	0	0	0	0	0
Lespedeza capitata	0	0	0	0	0	0
Lespedeza cuneata	0	0	0	2	0	0
Lespedeza stipulasia	4	0	0	1	2	5
Lespedeza violacea	0	0	0	0	0	0
Lespedeza virginica	3	1	4	0	0	0
Liatris aspera	0	0	0	0	0	0
Liatris pychnostachya	3	0	2	0	0	0
Linum rigidum	2	3	1	0	2	3
Lithospermum incisum	0	0	0	0	0	0
Lobelia spicata	5	0	4	0	0	0
Lollium perenne	0	0	0	0	0	0
Ludwigia alternifolia	1	0	0	0	0	0
Medicago lupulina	0	0	0	0	2	0
Melilotus officinale	0	0	0	0	6	0
Mentzelia oligosperma	0	0	0	0	0	0
Mimosa nuttalli	3	7	7	0	0	1
Mirabilis nyctaginea	0	0	0	0	0	1
Monarda clinopodoides	0	0	0	0	5	0
Monarda fistulosa	0	0	0	0	0	0
Oxalis stricta	4	5	5	5	5	5
Oxalis violacea	0	0	0	0	0	0
Panicum anceps	0	0	0	0	0	0
Panicum microcarpon	5	0	7	0	0	0
Panicum oligosanthes v.	0	5	2	5	4	5
Panicum virgatum	13	8	7	14	8	14

SPECIES	Carter	Flushe	White oak	Copan	Wattenb	TGPP
Paspalum floridanum	0	0	0	0	0	0
Paspalum setaceum	5	3	2	0	0	0
Penstemon tubaeflorus	2	3	0	0	2	0
Phalaris caroliniana	0	0	0	0	0	0
Phlox pilosa	0	0	0	0	0	0
Physostegia angustifolia	4	0	3	0	0	0
Plantago aristata	0	4	0	0	0	0
Plantago virginica	0	0	0	0	0	4
Poa pratensis	0	0	0	0	0	0
Polygala incarnata	4	3	1	2	1	0
Polygala sanguinea	5	3	4	0	0	0
Polytaenia nuttallii	5	4	0	0	2	0
Potentilla recta	0	0	0	0	0	0
Potentilla simplex	0	0	1	0	0	0
Prunella vulgaris	0	0	0	0	0	0
Pseudognaphalium obtusifolium	2	0	0	0	0	0
Psoralidium tenuiflorum	0	0	0	0	4	2
Ptilimnium capillaceum	7	8	2	5	0	0
Pycnanthemum tenuifolium	16	3	3	0	0	0
Pyrropappus carolinianus	0	0	0	0	0	0
Rhus copallina	0	0	0	0	0	0
Rhynchospora globularis	1	0	0	0	0	0
Rosa multiflora	0	0	1	0	0	0
Rosa setigera	0	0	0	0	0	0
Rubus allegheniensis	0	0	0	0	0	0
Rubus sp.	4	0	0	0	0	0
Rubus trivialis	0	0	0	0	0	0
Rudbeckia grandiflora	0	0	0	0	0	0
Rudbeckia hirta	5	5	5	5	4	0
Ruellia humilis	1	3	3	4	5	3
Rumex crispus	0	0	0	1	0	0
Sabatia angularis	0	0	0	0	0	0
Sabatia campestre	0	0	0	5	0	0
Salvia azurea	0	0	0	0	1	0
Sassafrass albidum	0	0	0	0	0	0
Schizachirium scoparium	29	64	28	22	30	23
Scirpus pendulus	3	0	0	0	0	0
Scirpus sp.	0	0	0	1	0	0
Scleria pauciflora	4	1	0	0	0	0

SPECIES	Carter	Flushe	White oak	Copan	Wattenb	TGPP
Scutellaria resinosa	0	0	0	0	0	0
Setaria geniculata	5	4	3	1	1	2
Silphium laciniatum	1	2	3	0	6	0
Solanum carolinense	0	1	0	0	0	3
Solanum dimidatum	0	0	0	0	0	0
Solidago missouriensis	0	2	0	2	5	0
Solidago rigida	0	0	0	0	2	0
Sonchus asper	0	0	0	0	0	0
Sorghastrum nutans	14	10	22	5	11	11
Spiranthes cernua	0	0	0	0	0	0
Sporobolus asper	0	4	0	10	7	23
Stillingia sylvatica	0	2	0	0	0	0
Strophostyles leiosperma	0	0	0	0	0	5
Stylosanthes biflora	1	1	1	0	0	0
Symphoricarpos orbiculatus	0	0	0	0	0	1
Symphyotrichum ericoides	0	0	0	0	5	5
Symphyotrichum patens	7	0	5	1	0	0
Taraxacum officinale	0	0	0	0	0	0
Tephrosia virginica	5	7	5	0	0	0
Tragia betonicifolia	0	0	0	0	0	0
Tragia urticifolia	0	2	0	0	1	1
Trifolium dubium	1	0	0	0	0	0
Triodanis perfoliata	0	0	0	0	0	0
Tripsicum dactyloides	0	0	0	0	0	2
Valerainella radiata	0	0	0	0	0	0
Vernonia baldwinii	0	0	0	0	0	4
Vernonia fasciculata	0	0	0	1	0	0
Viola sp	0	0	1	0	2	0
Vulpia octoflora	0	0	0	0	0	0

Table 2: continued

SPECIES	Gruber	Kyler	Mean cover	Frequency
Acer saccharum	0	0	0.1	1
Achillea millifolium	1	0	1.6	10
Agrostis hyemalis	0	0	0.2	1
Amaranthus sp.	0	1	0.1	2
Ambrosia artemisifolia	1	6	2.5	12
Ambrosia bidentata	0	1	0.1	1
Amorpha canascens	0	4	1.6	10
Amoselinum popei	0	0	0.3	2
Andropogon gerardii	7	60	36.3	19
Antennaria plantaginifolia	5	0	1.6	10
Apocynum cannabium	0	2	0.1	1
Aristida purpurea	11	0	1.6	6
Arnoglossum plantagineum	0	0	0.3	2
Artemisia ludoviciana	0	0	0.5	1
Asclepias incarnata	0	0	0.1	1
Asclepias sp	0	0	1.2	7
Asclepias stenophylla	0	0	0.7	5
Asclepias tuberosa	0	1	0.1	1
Asclepias verticillata	0	3	0.3	3
Asclepias viridiflora	0	0	0.7	3
Asclepias viridis	0	4	1.3	8
Astranthium integrifolium	0	0	0.2	1
Baptisia alba	0	3	2.0	11
Baptisia australis	0	0	0.2	4
Baptisia bracteata	0	0	0.5	2
Bothriochloa saccharoides	0	0	0.1	1
Bouteloua curtipendula	0	6	1.9	8
Bromus japonicus	0	0	1.7	6
Buchnera americana	0	0	0.6	4
Calopogon oklahomensis	0	0	0.1	1
Calylophus hartweggii	0	0	0.1	1
Carduus nutans	0	0	0.2	2
Carex crawei	0	7	3.8	6
Carex meadii	0	0	0.8	3
Castelleja indivisa	0	0	0.4	3
Ceanothus americanus	0	1	0.1	1
Cerastium brachypodium	0	0	0.3	2

SPECIES	Gruber	Kyler	Mean cover	Frequency
Chamaecrista fasiculata	1	0	0.4	3
Cirsium altissimum	0	0	0.6	1
Cirsium undulatum	0	0	0.3	6
Coelorachis cylindrica	0	0	1.9	4
Collinsia violacea	0	0	0.4	4
Conyza canadensis	0	0	0.1	1
Coreopsis grandiflora	0	0	0.9	5
Coreopsis palmata	0	0	0.2	3
Coreopsis tinctoria	0	0	2.3	10
Croton capitatus	0	5	0.4	2
Cynodon dactylon	0	0	0.5	2
Cyperus ovularis	2	1	1.0	8
Cyperus setigerus	0	0	0.3	2
Dalea candida	0	0	0.3	2
Dalea purpurea	0	4	1.3	9
Desmodium illinoense	1	5	0.7	5
Desmodium sessilifolium	0	0	0.2	1
Dianthus ameria	0	0	0.1	1
Dichanthelium acuminatum	0	0	0.7	4
Dichanthelium oligosanthes	8	0	0.6	3
Dichanthelium sphaerocarpon	0	0	0.1	1
Diospyros virginica	3	0	0.4	3
Echinacea pallida	0	1	0.6	3
Elymus canadensis	0	0	0.9	1
Elymus virginica	0	0	1.7	6
Eragrostis sp.	4	0	1.7	6
Eragrostis spectabilis	0	7	0.4	1
Eragrostis trichodes	0	0	0.4	2
Erigeron annuus	0	0	0.3	1
Erigeron strigosus	1	2	3.0	15
Eryngium yuccifolium	0	0	1.5	9
Eupatorium serotinum	0	0	0.3	1
Euphorbia corolata	0	0	0.8	8
Euphorbia hexagonoptea	0	0	0.1	1
Festuca arundinacea	5	0	1.7	12
Fimbristilis puberula	0	0	0.8	2
Fiurena simplex	4	0	0.2	1
Gaillardia pulchella	0	0	0.4	2
Grindelia squarrosa	0	0	0.1	1

SPECIES	Gruber	Kyler	Mean cover	Frequency
Hedeoma hispidum	0	0	0.2	1
Helenium amarum	0	0	0.1	1
Helenium flexuosum	0	0	0.1	1
Helianthus annuus	0	0	0.1	1
Helianthus mollis	3	0	2.2	9
Hieracium longipilum	1	1	0.4	6
Hordeum pusillum	0	0	0.4	2
Juncus interior	2	0	0.9	5
Juncus marginatus	0	0	0.9	5
Juncus scirpoides	2	0	1.2	7
Juniperus virginiana	0	0	0.1	1
Koeleria cristata	0	0	0.9	7
Krigia caespitosa	0	0	0.1	2
Lepidium campestre	0	0	0.1	1
Lespedeza capitata	0	0	0.0	
Lespedeza cuneata	6	0	2.9	5
Lespedeza stipulasia	4	0	2.9	15
Lespedeza violacea	1	1	0.1	2
Lespedeza virginica	0	0	1.0	8
Liatris aspera	1	0	0.1	1
Liatris pychnostachya	3	0	0.8	5
Linum rigidum	2	5	1.7	12
Lithospermum incisum	0	0	0.2	1
Lobelia spicata	1	0	1.9	11
Lollium perenne	0	0	0.1	1
Ludwigia alternifolia	0	0	0.1	1
Medicago lupulina	0	0	0.1	1
Melilotus officinale	0	0	0.4	2
Mentzelia oligosperma	0	0	0.3	5
Mimosa nuttalli	0	6	2.6	12
Mirabilis nyctaginea	0	0	0.1	1
Monarda clinopodoides	0	0	0.3	1
Monarda fistulosa	1	0	0.1	1
Oxalis stricta	0	5	3.2	17
Oxalis violacea	0	0	0.2	3
Panicum anceps	2	0	0.3	2
Panicum microcarpon	0	0	1.1	4
Panicum oligosanthes v.	0	10	5.3	16
Panicum virgatum	61	3	10.0	16

SPECIES	Gruber	Kyler	Mean cover	Frequency
Paspalum floridanum	0	0	0.5	2
Paspalum setaceum	4	0	3.3	13
Penstemon tubaeflorus	0	0	0.5	7
Phalaris caroliniana	0	0	0.4	2
Phlox pilosa	0	0	0.2	1
Physostegia angustifolia	0	0	1.3	7
Plantago aristata	0	0	1.6	7
Plantago virginica	5	0	1.1	6
Poa pratensis	0	0	0.9	4
Polygala incarnata	4	5	1.6	11
Polygala sanguinea	5	0	1.9	11
Polytaenia nuttallii	0	0	0.9	6
Potentilla recta	0	0	0.1	1
Potentilla simplex	0	0	0.1	1
Prunella vulgaris	0	0	0.1	1
Pseudognaphalium obtusifolium	0	0	0.9	8
Psoralidium tenuiflorum	0	0	0.8	5
Ptilimnium capillaceum	2	5	2.4	10
Pycnanthemum tenuifolium	3	0	1.7	7
Pyrropappus carolinianus	0	0	0.1	1
Rhus copallina	14	0	0.7	1
Rhynchospora globularis	0	0	0.2	2
Rosa multiflora	0	0	0.3	2
Rosa setigera	0	0	0.1	1
Rubus allegheniensis	0	0	1.0	1
Rubus sp.	1	0	0.5	3
Rubus trivialis	0	0	0.1	1
Rudbeckia grandiflora	0	0	0.3	2
Rudbeckia hirta	5	0	4.2	18
Ruellia humilis	0	0	2.5	13
Rumex crispus	0	0	0.4	3
Sabatia angularis	0	0	0.1	1
Sabatia campestre	2	0	0.7	6
Salvia azurea	0	1	0.1	2
Sassafrass albidum	1	0	0.1	1
Schizachirium scoparium	28	33	34.3	19
Scirpus pendulus	0	0	0.2	1
Scirpus sp.	2	0	0.2	3
Scleria pauciflora	5	5	1.1	6

SPECIES	Gruber	Kyler	Mean cover	Frequency
Scutellaria resinosa	0	0	0.1	1
Setaria geniculata	7	2	3.4	13
Silphium laciniatum	0	0	0.7	6
Solanum carolinense	0	0	0.4	5
Solanum dimidatum	0	0	0.1	1
Solidago missouriensis	3	2	1.6	13
Solidago rigida	0	0	0.3	2
Sonchus asper	1	0	0.1	1
Sorghastrum nutans	5	8	13.1	18
Spiranthes cernua	0	0	0.2	3
Sporobolus asper	8	8	9.7	14
Stillingia sylvatica	0	0	0.4	2
Strophostyles leiosperma	2	0	0.4	2
Stylosanthes biflora	0	4	0.6	6
Symphoricarpos orbiculatus	0	0	0.3	3
Symphyotrichum ericoides	1	6	1.1	5
Symphyotrichum patens	0	0	1.9	11
Taraxacum officinale	0	0	0.1	1
Tephrosia virginica	0	1	1.0	6
Tragia betonicifolia	0	0	0.1	1
Tragia urticifolia	0	0	0.2	3
Trifolium dubium	0	0	0.1	2
Triodanis perfoliata	0	0	0.3	2
Tripsicum dactyloides	0	0	0.1	1
Valerainella radiata	0	0	0.4	2
Vernonia baldwinii	2	0	0.8	4
Vernonia fasciculata	0	2	0.2	2
Viola sp	0	0	0.4	3
Vulpia octoflora	0	0	0.1	1

Table 3: Species richness (S), evenness (E), and diversity values (H') for twenty northeastern Oklahoma hay meadow sites.

Name	S	E	H'
Jeter	37	0.904	3.264
Hall	23	0.849	2.661
Delozier	46	0.863	3.306
Heuerter	53	0.875	3.474
Stambaugh	37	0.852	3.076
Keys	29	0.817	2.751
Moore	40	0.813	2.998
Morrow	45	0.809	3.08
McGowen	38	0.764	2.777
Forrest	35	0.844	3.001
Pryor	42	0.808	3.021
Easley	56	0.716	2.883
Carter	58	0.908	3.689
Flushe	49	0.843	3.282
White Oak	51	0.848	3.336
Copan WMA	27	0.752	2.478
Wattenbarger	40	0.825	3.042
Tallgrass Prairie Preserve	37	0.836	3.019
Camp Gruber	50	0.819	3.202
Kyler	40	0.816	3.008
Averages:	41.7	0.828	3.067

Table 4: Prairie hay meadow sites reconnoitered in 1998 for *Platanthera praeclara* in northeast Oklahoma.

Site name	Township	Range	Section	County	Site rank
Banzet	T29N	R20E	SW/4 sec. 33	Craig	B
Welch #1	T29N	R19E	NE/4, NW/4 sec. 25	Craig	B
Welch #2	T29N	R19E	NE/4 sec. 27	Craig	B
Welch #3	T29N	R19E	N/2, NE/4 sec. 36	Craig	B
Hayrick #1	T29N	R18E	NW/4, NE/4 sec. 29	Craig	B
Hollow #1	T29N	R18E	NW/4, NE/4 sec. 28	Craig	B
Hollow #2	T29N	R18E	NW/4, NW/4 sec. 1	Craig	A
Timber Hill #1	T27N	R20E	NW/4, SW/4 sec. 16	Craig	C
Estella #1	T26N	R19E	W/2, SE/4 sec. 18	Craig	B
Estella #2	T26N	R19E	NW/4 sec. 17	Craig	B
Estella #3	T26N	R19E	SW/4, SW/4 sec. 15	Craig	B
Craig #1	T25N	R20E	SW/4, SE/4 sec. 8	Craig	B
Craig #2	T25N	R20E	SW/4, SW4 sec. 9	Craig	B
Hwy 66 #3	T24N	R19E	SE/4, NE/4 sec. 5	Craig	A
Strang #1	T23N	R19E	SE/4, SE/4 sec. 36	Mayes	A
Strang #2	T23N	R19E	SW/4, SW/4, sec. 36	Mayes	B
Wat Henry	T23N	R20E	SW/4 sec. 31	Mayes	B
Adair #1	T23N	R19E	SE/4, SE/4 sec. 27	Mayes	B
Hwy.28 #1	T23N	R18E	SW/4, SE/4 sec. 28	Mayes	C
Hwy. 28 #2	T23N	R18E	S/2 sec. 29	Mayes	A
Hwy. 28 #3	T23N	R18E	NW/4, NE/4 sec. 32	Mayes	B
Adair Cemetery	T24N	R19E	NE/4, SE/4 sec. 34	Mayes	B

Site name	Township	Range	Section	County	Site rank
Muskogee #1	T14N	R17E	S/2 sec. 6	Muskogee	B
Muskogee #2	T14N	R17E	E/2 sec. 7	Muskogee	B
Katy #1	T29N	R16E	NE/4, NE/4 sec. 22	Nowata	B
Katy #2	T29N	R16E	NE/4, NE/4 sec. 21	Nowata	C
Hayrick Mound	T29N	R17E	NW/4 sec. 29	Nowata	B
Hayrick Mound #2	T29N	R17E	SW/4, NW/4 sec. 20	Nowata	B
Elliot #1	T28N	R15E	SW/4, NW/4 sec. 26	Nowata	B
Elliot #2	T28N	R15E	SW/4 sec. 21	Nowata	B
Delaware #1	T27N	R15E	NW/4, NW/4, sec. 29	Nowata	A
Delaware #2	T27N	R15E	S/2,Sw/4, sec. 21	Nowata	A
Delaware #3	T27N	R15E	SW/4, SW/4 sec. 22	Nowata	B
Baird Cattle Co.	T26N	R14E	SE/4, SE/4 sec. 2	Nowata	C
Doenges Ranch	T26N	R14E	S/2 NE/4 sec.11	Nowata	C
Nowata #1	T26N	R14E	SW/4, NW/4 sec. 25	Nowata	A
Nowata #2	T26N	R14E	NW/4, SE/4 sec. 23	Nowata	A
Nowata #3	T26N	R14E	NW/4, NW/4 sec.19	Nowata	A
Ottawa #1	T29N	R23E	NE/4, NE/4 sec. 23	Ottawa	B
Ottawa #2	T29N	R23E	NE/4, NW/4 sec.23	Ottawa	B
Hwy. 66 #1	T24N	R18E	NE/4, SE/4 sec. 22	Rogers	B
Hwy. 66 #2	T24N	R18E	SE/4, NE/4 sec. 22	Rogers	B
Rogers #1	T22N	R14E	E/2, NE/4 & E/2, SE/4 sec.34	Rogers	B
Rogers #2	T22N	R14E	SE/4, SE/4 sec. 27	Rogers	B
Rogers #3	T22N	R14E	W/2, SW/4 sec. 26	Rogers	B
Rogers #4	T22N	R14E	SW/4, SW/4 S. 23	Rogers	B

Site name	Township	Range	Section	County	Site rank
Rogers #5	T22N	R14E	NE/4, SE/4 sec. 22	Rogers	B
Wash #1	T29N	R13E	S/2, SE/4 & N/2, NE/4 sec. 26	Washington	B
Wash #2	T29N	R13E	W/2, SW/4 sec. 24	Washington	B
Wash #3	T29N	R13E	W/2, NW/4 sec. 25	Washington	B
Copan #1	T29N	R13E	N/2, N/2, NE/4 sec. 35	Washington	B
Wash #4	T29N	R12E	E/2 sec.1	Washington	C
Wash #5	T23N	R13E	SE/4, SW/4 sec.19	Washington	C
Wash #6	T23N	R13E	N/2, NW/4 sec. 30	Washington	B
Wash #7	T23N	R13E	SE/4, SE/4 sec. 20	Washington	C
Wash #8	T23N	R13E	NE/4, NE/4 sec.10	Washington	C

Figure 1: Location of 20 native hay meadows quantitatively sampled in northeast Oklahoma.

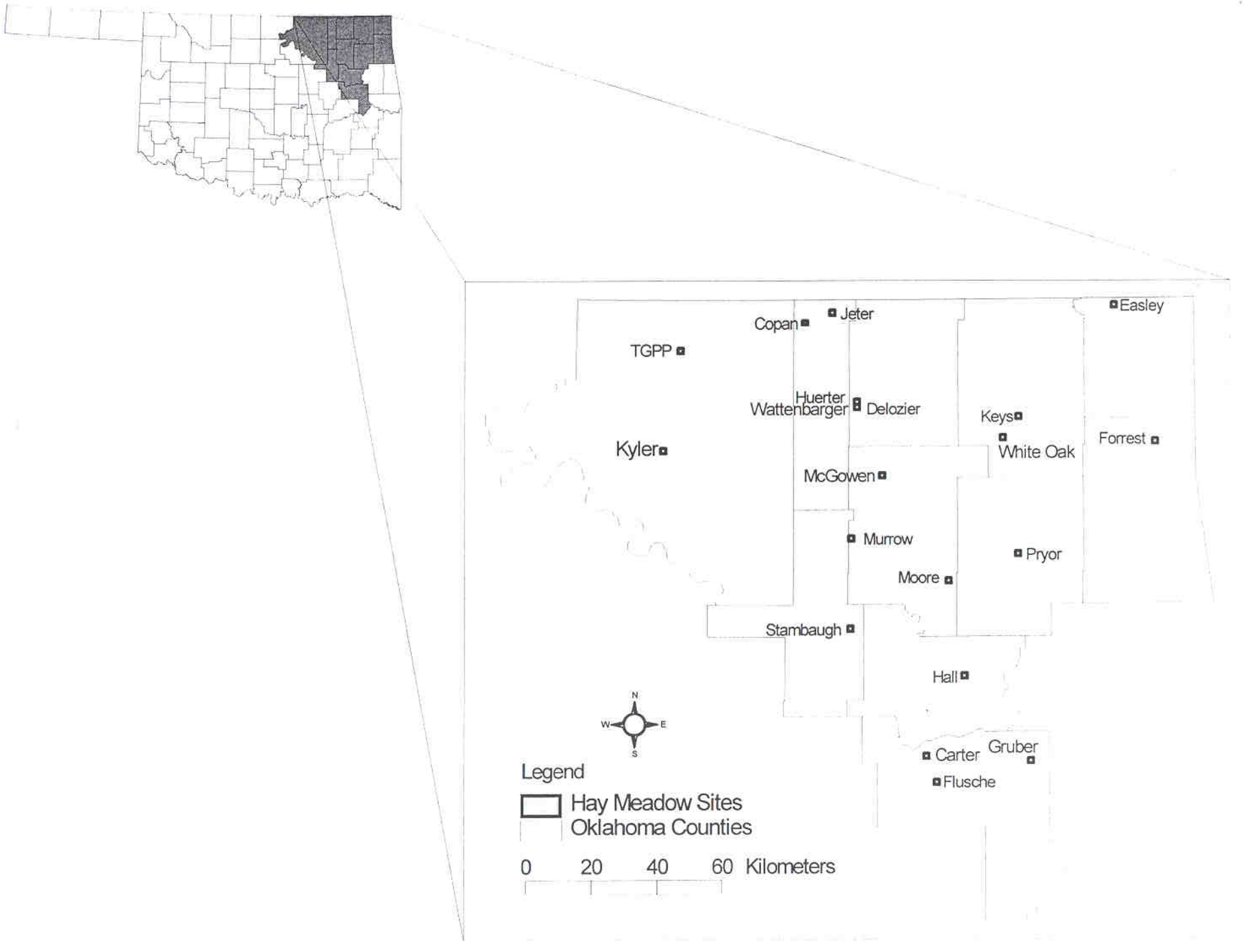
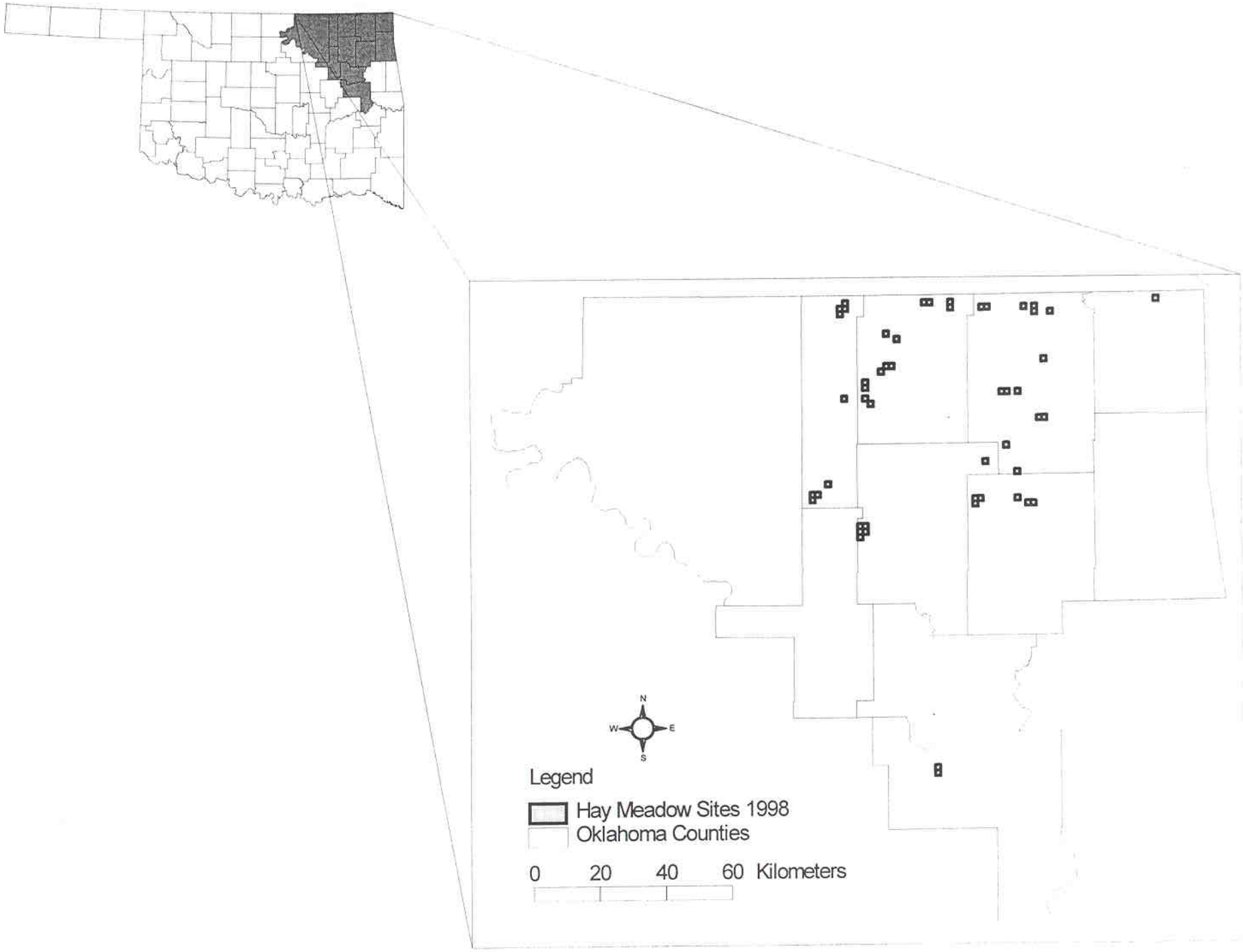

Easley
Jeter
Copan
TGPP
Huerter
Wattenbarger
Delozier
Keys
White Oak
Forrest
Kyler
McGowen
Murrow
Pryor
Moore
Stambaugh
Hall
N
W
E
S
Carter
Gruber
Flusche
Legend
Hay Meadow Sites
Oklahoma Counties
0 20 40 60 Kilometers

Figure 2: Locations of 56 native hay meadows reconnoitered for presence of Platanthera praeclara populations in 1998.


N
W
E
S
Legend
Hay Meadow Sites 1998
Oklahoma Counties
0 20 40 60 Kilometers

Appendix 1: Examples of site survey and community reconnaissance forms used by biologists at the Oklahoma Natural Heritage Inventory.

SITE SURVEY SUMMARY

Site Name:_____

Quad Names:_____

Quad Codes:_____

*Lat/Long:_____ State: OK County:_____

Township/Range/Section:_____

Field Quad Margin #:_____

First Site Visit

Date:_____ Time:_____to_____ Source Code:_____

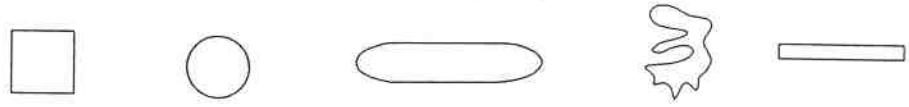
Surveyors:_____

Comments/Survey Methods:_____

_____

Check if an addendum of additional visits is attached: yes___

Circle **Shape** most similar to site:
(see directions)



e.g. Tract Watershed Riparian Complex Ditch Other

Source of Lead:_____

Others knowledgeable about site:_____

Ownership / Managed Area Name / Contact Name (names, addresses, phone #).

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

Directions to site - Starting from a landmark, concisely describe the location using distance (mileage) and landmarks. Please provide directions to specific elements if these occurrences would be difficult to relocate using maps.
Map to site attached? ___ yes ___ no

_____

_____

_____

_____

_____

* May be filled out by ONHI

INDEX

Element Name:	List species/communities sought, found, or reported from site.
Code:	Number or letter to identify elements on base map.
Occurrence #:*	Indicate Element Occurrence (EO) number if known.
Area:	Size of area occupied by element in acres.
Found:	Yes, no, or N/A whether the element was found on that date.
Transcribe:*	Yes, no, or N/A if the EOR is to be transcribed or updated. For communities, this decision should be based on minimum area and shape criteria specified in the CCA.
Return visit:	Yes, no, or N/A if a return visit is required.

Check if copies of this form are attached for additional dates or elements: yes_____

				Date:										
Element Name	Code	Occ.#	Area	F	T	F	T	F	T	F	T	F	T	Return

* May be filled out by ONHI

Written Description of Biotic Features of the site including vegetation, significant species, etc.: _____

_____

_____

_____

_____

Written Description of Abiotic Features of the site including aquatic features, notable landforms, substrates, scenic qualities, natural hazards, etc:_____

_____

_____

_____

_____

Substrate: Bedrock___ Gravel___ Silt___ Loam___ Clay___ Comments:_____

Topographic Base Map - Attach a copy of a portion of a topographic map(s) showing site. Aerial photographs may be used. On the map &/or photo note:

Completed?

1. yes__ no__ Precise element locations (dots) &/or boundaries (solid lines). Identify each element with the codes on page 1.

2. yes__ no__ Draw preliminary PRIMARY (+-+-+-) ecological site boundaries of all known element occurrences and lands necessary to viability (e.g. habitat, watershed).

   Explain how drawn:_____

   _____

   _____

3. yes__ no__ Draw preliminary SECONDARY (-+ + -+ + -+ +) ecological site boundaries or "buffer", that includes lands intended to mitigate future unforeseen negative impacts to the EO's (i.e. erosion control, trespass-related damage, natural succession, exotic species, urban sprawl, climate change). This may include a topographic range or a 3 mile (5 km) radius for a large species pool in case of climate change. Use -+-+ + -+-+ + where primary and secondary boundaries coincide.

   Explain how drawn:_____

   _____

   _____

For each of the given categories, please indicate Yes, No, or estimate % area of each from survey, topographic maps etc. if possible.

Landuse and covertypes on the site:

Agriculture: Cropland___ Pasture/Range___ Timberland___ Other_____

Industry: Oil/Gas___ Mining___ Urban___ Roads/Bridges___ Other_____

Natural: Forests___ Shrublands___ Grasslands___ Wetlands___ Streams___ Ponds/reservoirs___ Other:_____

Comments:_____

_____

Disturbances visible on site:

Grazing___ Fire___ Dumping___ Hunting/Trapping___ Recreation___ Buildings___ Logging___ Plantations___

Exotic Species___ Roads/Bridges___ Dams/Weirs___ Spraying___ Effluent Discharge___ Other:_____

Comments:_____

_____

Landuse within the PRIMARY boundaries: (e.g. watershed or uphill):

Agriculture: Cropland___ Pasture/Range___ Timberland___ Other_____

Industry: Oil/Gas___ Mining___ Urban___ Roads/Bridges___ Other_____

Natural: Forests___ Shrublands___ Grasslands___ Wetlands___ Streams___ Ponds/reservoirs___ Other:_____

Comments:_____

_____

Landuse surrounding site in **SECONDARY** boundaries (e.g. buffer or 3 mi radius):

Agriculture: Cropland___ Pasture/Range___ Timberland___ Other_____

Industry: Oil/Gas___ Mining___ Urban___ Roads/Bridges___ Other_____

Natural: Forests___ Shrublands___ Grasslands___ Wetlands___ Streams___ Ponds/reservoirs___ Other:_____

Comments:_____

_____

Summary of threats to site/Management needs - On-site and off-site threats and management implications. If applicable, discuss why species/communities are no longer present.

_____

_____

_____