THE VASCULAR FLORA OF THE NORTH CENTRAL TEXAS WALNUT FORMATION

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ABSTRACT

Political boundaries frequently define local floras. This floristic project takes a geological approach inspired by *Dalea reverchonii* (Comanche Peak prairie clover), which is primarily endemic to glades of the Walnut Formation. The Cretaceous Walnut Formation (Comanchean) lies on the drier western edge of the Fort Worth Prairie in North Central Texas. Its shallow limestone soils, formed from alternating layers of hard limestone and clayey marl, support a variety of habitats. Glades of barren limestone typically appear on ridgetops, grassland savannas form on eroding hillslopes, and seeps support diverse hyperseasonal vegetation. Vouchers were collected from January 2010 to June 2012 resulting in 469 infraspecific taxa, 453 species in 286 genera and 79 families. The richest five plant families are Asteraceae (74 taxa), Poaceae (73), Fabaceae (34), Euphorbiaceae (18), and Cyperaceae (17). There are 61 introduced species. Results indicate floristic affinities to limestone cedar glades of the Southeastern United States, the Edwards Plateau of Central Texas, and calcareous Apacherian Savannas of Southwestern North America.

RESUMEN

Las fronteras políticas definen frecuentemente las floras locales. Este proyecto florístico toma una aproximación geológica inspirada en *Dalea reverchonii* (trébol de la paradera de Comanche Peak), que es primariamente endémico de los claros de la formación Walnut. La formación Cretácica Walnut (Comancheana) está en el borde oeste más seco de la pradera de Fort Worth en el Norte-Centro de Texas. Sus suelos calcáreos poco profundos, formados por capas alternas de calizas duras y margas arcillosas, soportan una variedad de hábitats. Aparecen típicos claros de calizas estériles en las cumbres, sabanas herbáceas en las laderas erosionadas, y filtraciones soportan una vegetación hiperestacional diversa. Se colectaron testigos des enero de 2010 a junio de 2012 dando como resultado 469 taxa infraspecíficos, 453 especies in 286 géneros y 79 familias. Las cinco familias de plantas más ricas son Asteraceae (74 taxa), Poaceae (73), Fabaceae (34), Euphorbiaceae (18), y Cyperaceae (17). Hay 47 especies exóticas. Los resultados indican afinidades florísticas con las calizas de cedar glades del sureste de los Estados Unidos, el Edwards Plateau del centro de Texas, y sabanas calcáreas Apacherianas del suroeste de Norte América.

INTRODUCTION

In Texas, few floras have been published, and these traditionally have been defined by political boundaries such as Neill's flora of Madison County, Texas (Neill & Wilson 2000). Correll and Johnston's *Manual of the Vascular Plants of Texas* (1970) is the only statewide flora, published 42 years ago. Floras completed in Texas are seldom published in peer-reviewed journals, and many languish as theses hidden in university libraries. These are often merely checklists of species encountered during the survey, lacking detailed ecological data. While checklists are critical baselines, more useful insights are possible with associated ecological information.

Cuyler (1931) and Tharp (1939) both stated that geology is often a strong determinant for vegetation. Kruckeberg (2004) provides an impeccable argument for the importance of geology and landform on plant communities. Yet, floras and herbarium specimens rarely include geological data—information often valuable for understanding rare and endemic species. This study has a geological context inspired by these works and the endemic *Dalea reverchonii* (Comanche Peak prairie clover).

Dalea reverchonii (Fabaceae), endemic to North Central Texas, was first collected on Comanche Peak in Hood County, 1876 by Julien Reverchon. Originally described as *Petalostemum reverchonii*, it was not found again until the early 1980s (Mahler 1984). Subsequent collections revealed that *D. reverchonii* is almost restricted to rocky glades and barrens of the Walnut Formation (O'Kennon pers. comm.). This contradicts Poole

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et al. (2007), who stated *D. reverchonii* is observed only on Goodland Limestone. There is one exception: at the type locality on the butte of Comanche Peak, the only population found south of the Brazos River, *D. reverchonii* grows on Edwards Limestone; thus it is not strictly endemic to the Walnut Formation. There may be other undiscovered populations south of the Brazos River and on other formations.

While much of North Central Texas geology is limestone or chalk, the extensive glades of the Walnut Formation are structurally and floristically unique to the region. Over a century ago William Bray, an early Texas plant ecologist, stated, "before the flora of Texas suffers further radical changes, the schools of the state ought to cooperate in securing a complete and authentic list of species represented by carefully collected and well-preserved specimens" (Bray 1906). Since then, Texas has witnessed accelerated urban development, yet we still lack basic knowledge of the state's natural history. This vascular flora of the North Central Texas Walnut Formation combines the goals of securing vouchered specimens and generating an ecologically relevant circumscription of a floristic area.

This project had three objectives: 1) Collect, identify, and archive specimens of the vascular plants found on the northern portion of the Walnut Formation as mapped by the Geologic Atlas of Texas (McGowen et al. 1987, 1991); 2) List all species and delineate their preferred habitats, including major plant associations with relevant geological, pedological, and hydrological data; and 3) Analyze the flora for rare, endemic, invading, and disjunct taxa.

Geographical Context

Names among different treatments designating physiographic regions, vegetation areas, and ecoregions differ; thus the area covered by this flora has been included in different geographic contexts which are reviewed below.

Four currently recognized ecoregions dominate North Central Texas north of the Brazos River: running west to east, the West Cross Timbers, Fort Worth or Grand Prairie, East Cross Timbers, and Blackland Prairie (Fig. 1). In his monograph on Texas vegetation east of the 98th parallel, Tharp (1926) did not distinguish the better-known Blackland Prairie, which begins near Dallas, from the Grand Prairie; however, Hill (1901) described key differences between the two prairies. The Grand Prairie is much flatter and has more angular scarps than the gentle rolling plains of the Blackland Prairie. Shallower soils and bedrock of erosion-resistant limestone strata alternating with softer sediments distinguish the Grand Prairie, which is recognized by the name "hard lime rock region," where limestone-topped cuestas and mesas are part of the landscape (Hill 1901). The Blackland Prairie is underlain by chalk and shale, which weather deeply to form characteristic black, calcareous, heavy clay soils (Diggs et al. 1999). The Blackland Prairie is a true tallgrass prairie dominated by *Andropogon gerardii, Panicum virgatum, Schizachyrium scoparium, Sorghastrum nutans,* and *Tripsacum dactyloides,* with wildflowers and occasional mottes. Only the Austin Chalk Formation is capable of forming escarpments in the Blackland Prairie region (Diggs et al. 1999, Hill 1901). The fertile, rich, deep clays, combined with new plowing technologies, allowed cotton farming to proliferate in the Blackland Prairie during the late 1800s, destroying much of the native tallgrass prairie (Diggs et al. 1999).

Hill, a geologist with a keen eye for landforms, defined the Grand Prairie physiographic subprovince as a "northern continuation of the Edwards Plateau" (1901). This subprovince extends from the Red River to the Colorado River, bounded on the east by the Eastern Cross Timbers and, farther south, by the Balcones Fault zone. "The northern and irregular western borders of the Grand Prairie terminate in the low inward-facing escarpment … which overlooks the valley of the Western Cross Timbers" (Hill 1901). This escarpment includes many of the Walnut Formation outcrops north of the Brazos River. Hill recognized two subdivisions of the main body of the Texas Grand Prairie: Fort Worth Type Prairie and Lampasas Cut Plain.

The Lampasas Cut Plain was described as "plains more scarped and dissected into numerous low buttes and mesas" (Hill 1901), starting south of the Trinity River in Parker County along the western edge of the Grand Prairie and increasing in width south of the Brazos River. This includes most of the Walnut outcrops in Parker and Johnson counties.

Hill's Fort Worth Type Prairies extend north and east of the Lampasas Cut Plain to the Red River. Hill

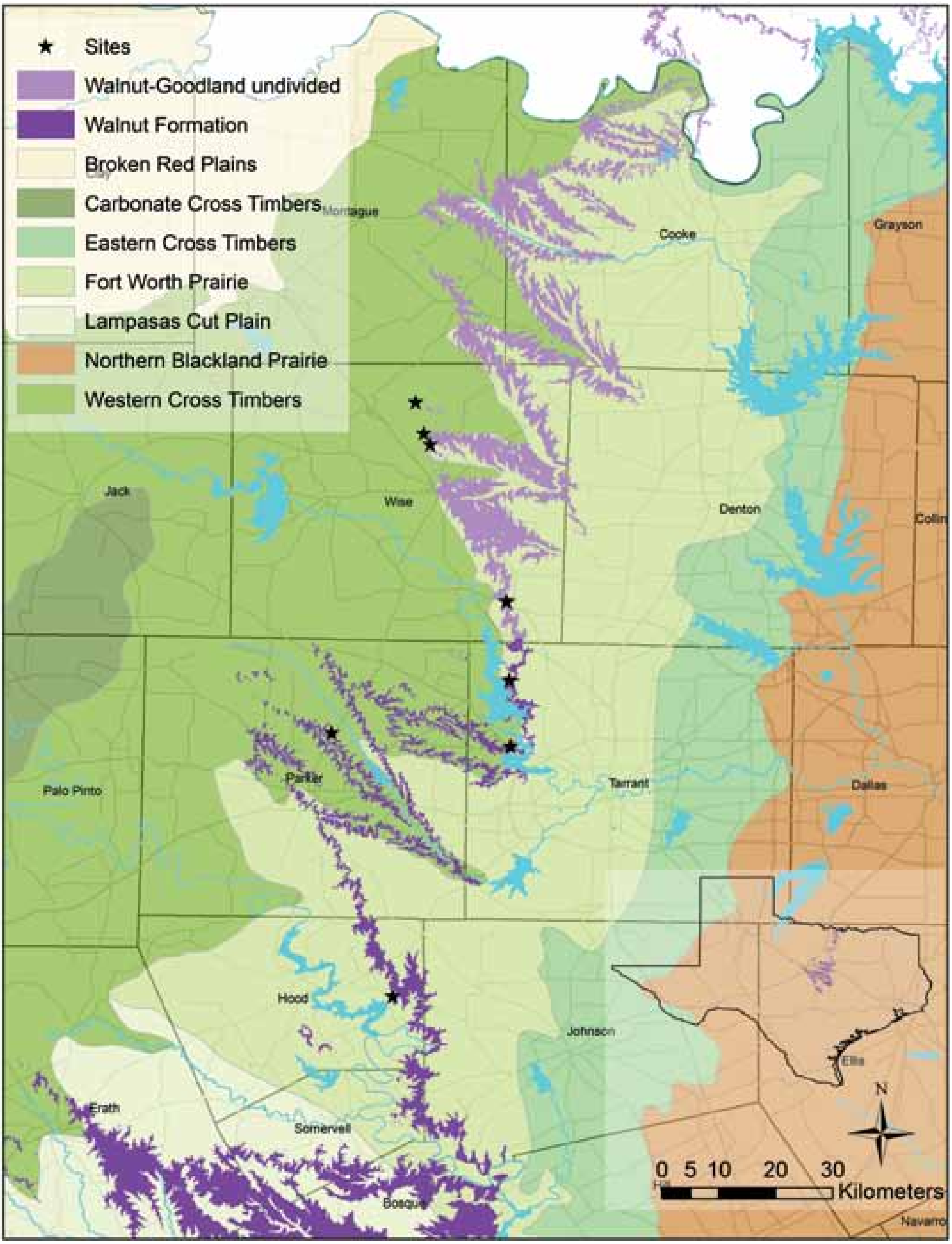

Fig. 1. The Walnut Formation and the undivided Walnut and Goodland formations in relation to the Level IV Ecoregions of Texas as described by Griffith et al. (2004) using the terminology from Hill (1901) and Diggs et al. (1999). In the bottom right is the extent of the Walnut Formation in Texas. Data adapted from Texas Natural Resources Information System and the Environmental Protection Agency.

described two subdivisions of Fort Worth Type Prairies north of the Brazos River, aligned approximately parallel between the two Cross Timbers. The Gainesville Prairie is to the east, and the 'true' Fort Worth Prairie is on the west in Tarrant, Denton, Wise, and Cooke counties. Thus, within the area of this flora, the northern Walnut outcrops are within Hill's Fort Worth Prairie, while the southern are included within the northward attenuation of Hill's Lampasas Cut Plain.

Dyksterhuis defined the Fort Worth Prairie as "the northern portion of the physiographic unit known as the Grand Prairie" (1946), and mapped it to cover all of Hill's province north of the Brazos River Valley, including areas of Parker, Hood, and Johnson counties that Hill considered Lampasas Cut Plain. Diggs et al. (1999) subdivided the Grand Prairie vegetational region into the Fort Worth Prairie north of the Brazos, as Dyksterhuis had, with the Lampasas Cut Plain to the south. In these maps, the area of this flora lies in the western edge of the Fort Worth Prairie.

Names are different in the *Ecoregions of Texas* map (Griffiths et al. 2004), which shows two hierarchical classification levels. At Level III, Texas Blackland Prairies are distinguished from Cross Timbers. Within the Cross Timbers Ecoregion, Level IV ecoregions are Eastern Cross Timbers, Western Cross Timbers, Grand Prairie, and Limestone Cut Plain. The Grand Prairie Ecoregion is between the East and West Cross timbers, extending from the Red River south to the Brazos Valley, corresponding to the Fort Worth Prairie as defined by Dyksterhuis (1946). Using the Environmental Protections Agency Level IV map, the area of this flora is along the western boundary of the Grand Prairie, with outliers in the nearby Western Cross Timbers.

The Fort Worth Prairie is described as a grassland historically devoid of trees except in waterways (Diggs et al. 1999; Dyksterhuis 1946). Dyksterhuis (1946), sampling between 1939 and 1944, found that *Nassella leucotricha* had the greatest coverage. Other common perennial grasses were *Aristida* spp., *Bothriochloa laguroides*, *Bouteloua curtipendula*, *Buchloe dactyloides*, *Schizachyrium scoparium,* and *Sporobolus compositus*. Among these, only *Schizachyrium scoparium* is considered typical of tallgrass prairie, and Dyksterhuis proposed that its relative abundance was negatively correlated with grazing disturbance (1946). Dyksterhuis emphasized that "the abundance of annuals is regarded as a most significant feature" of the Fort Worth Prairie, comprising about 20% of the vegetation (1946). Common annuals included cool season species such as *Bromus japonicus, Hordeum pusillum*, and *Plantago* spp., together with such warm season species as *Gutierrezia dracunculoides* and *Sporobolus vaginiflorus*. In the Grand Prairie Ecoregion description, *Sorghastrum nutans* and *Andropogon gerardii* are included as representative grasses (Griffiths et al. 2004), though Dyksterhuis (1946) indicated they were seldom dominant except in "relict" sites protected from grazing.

The upland soils of the Fort Worth Prairie differ from typical prairie soils. They are mapped as calcareous mollisols, inceptisols, and entisols (Ressel 1981). Immature soils overlie the limestone and clayey parent material, showing weakly developed horizons with high concentrations of calcium carbonate, clay, and organic matter (Dyksterhuis 1946). The xeric aspects of the Fort Worth Prairie are due to the structure of shallow calcareous soils, which retain limited moisture. Hill (1887) hypothesized that they have too much lime to support tree growth. The shallow soils and hard limestone make tilling impossible, and thus have encouraged cattle grazing as the primary land use (Diggs et al. 1999; Dyksterhuis 1946; Hill 1901). Today grazing pressure and fire suppression have had the greatest impact on the Fort Worth Prairie, promoting weedy species introduced for forage and species that can withstand grazing, and encouraging invasive woody species that were not present 60 years ago (Diggs et al. 1999; Dyksterhuis 1946).

The Western Cross Timbers border the western edge of the Fort Worth Prairie. Often the boundary occurs where the Walnut Formation abuts deep, non-calcareous, sandy soils derived from Paluxy and Antlers Formations. The Western Cross Timbers are strips of woodlands and savannas, intermixed with occasional prairie openings (Francaviglia 2000; Harris 2008; Kendall 1845; Tharp 1939). The arenaceous and siliceous, mildly acidic alfisols of the Western Cross Timbers create a matrix with adequate water storage, which tree roots can penetrate deeply (Dyksterhuis 1948; Harris 2008; Hill 1887; Sims and Risser 2000). *Quercus stellata* (post oak) and *Quercus marilandica* (blackjack oak) are the dominant trees, interspersed with elms, hackberries, and greenbriars (Dyksterhuis 1948; Harris 2008; Hill 1887; Kendall 1845; Tharp 1939). Washington Irving (1985) described these woodlands as "forests of cast iron" due their hardiness and density. The adaptations of post and blackjack oaks to moderate drought allow them to expand further westward than most other trees of the Eastern deciduous forest (Tharp 1939).

As noted above, the northern boundary of the Lampasas Cut Plain has differed tremendously over the last century (Diggs et al. 1999; Gould 1960; Griffith et al. 2004; Hill 1901). In the Lampasas Cut Plain, Hill described the most representative portion of the Walnut Formation, the Walnut Prairie; where the strata are more extensively exposed (Griffith et al. 2004; Hill 1901; McGowen et al. 1987). In this region, Walnut geology supports prairies on valley floors instead of more xeric uplands as in the Fort Worth Prairie. Kendall (1845) also noted a difference in the landscape as he crossed north of the Brazos River during his expedition. In the Lampasas Cut Plain, the Edwards Limestone outcrops more frequently as hard, resistant caps on the mesas and buttes. Southward, the Lampasas Cut Plain and Edwards Limestone are less dissected, forming the beginning of the Edwards Plateau.

Geology of the Walnut Formation

The Walnut Formation, underlying the western edge of the Fort Worth Prairie and parts of the Lampasas Cut Plain, is exposed in at least 18 counties in Texas, mostly south of the Brazos River (Sellards et al. 1932; United States Geological Survey 2010). Mapped as Walnut Clay, it is part of the Lower Cretaceous Fredericksburg Group, which formed during the Comanchean period 103 million years ago (McGowen et al. 1987, 1991). The Walnut Formation is largely composed of limestone and less consolidated strata variously termed marl, calcareous clay, or shale. It is about 23 m thick in Parker and Tarrant counties and about 8 m thick in Wise County, thinning inland north and west (Sellers et al. 1932; Scott et al. 2003). The Walnut Formation is thicker and more exposed farther south, eventually thinning again at the base of the Edwards Plateau (McGowen et al. 1987, 1991).

By nomenclatural convention, the Walnut Formation overlies the Paluxy Sandstone south of Decatur, Texas; whereas north, the Antlers Formation is beneath. The Glen Rose Formation defines the separation between the Paluxy and Twin Mountains Formations; however, the Glen Rose Formation is absent north of Decatur, forcing the combination of Paluxy and Twin Mountains into the Antlers Sands (McGowan et al. 1987; McGowen et al. 1991). For the remainder of Texas, the Glen Rose Limestone is the underlying formation instead of the Paluxy and Antlers sandstones (Fig. 2). This has been described as an unconformity because “the Paluxy was deposited in a regressive sea, which readvanced over the land, depositing the Walnut Formation” (Sellards et al. 1932).

The Goodland Limestone overlies the Walnut Formation in Parker and Tarrant counties and is undifferentiated from the Walnut on geologic maps in Wise and Montague counties, making outcrops harder to locate. Goodland Limestone can be distinguished from Walnut Limestone by its nodular fabric, paler whitish color, and decreased abundance of *Texigryphaea* fossils. In Hood, Johnson, and Somervell counties, nearer the Brazos River, the Goodland thins, the Walnut expands, and Comanche Peak and Edwards limestones are exposed as the overlying formations. The boundary between Goodland and Walnut Formations is not clearly defined. The lower Marys Creek Member of the Goodland Formation in Tarrant County has been traced southward to match the upper marl interval of the Walnut Formation beneath the Comanche Peak Formation, leading to the proposal that north of the Parker-Hood County line the Marys Creek Marl be considered part of the Goodland Formation; whereas to the south it is within the Walnut (Scott et al. 2003). The Walnut Formation is also known in Oklahoma, where it is associated with Goodland Limestone (Hill 1901), and in West Texas, where it is largely associated with the Edwards and Comanche Peak formations, as on Double Mountain in Stonewall County (Eifler 1993).

Hill (1901) described the Walnut Formation as clay and nonchalky limestones making up the base of the Fredericksburg Division, consisting of “alternations of calcareous laminated clays, weathering yellow on oxidation, semicrystalline limestone flags, and shell agglomerate. … In places they weather into rich black soils and make extensive agricultural belts” (Hill 1901). In the area of this flora, many Walnut Limestone strata are easily recognizable as coquinites or shell agglomerates dominated by fossil *Texigryphaea,* which are relict storm beds. Fresh exposures are blue in color and weather cream to yellow and olive in flaggy layers. Marls

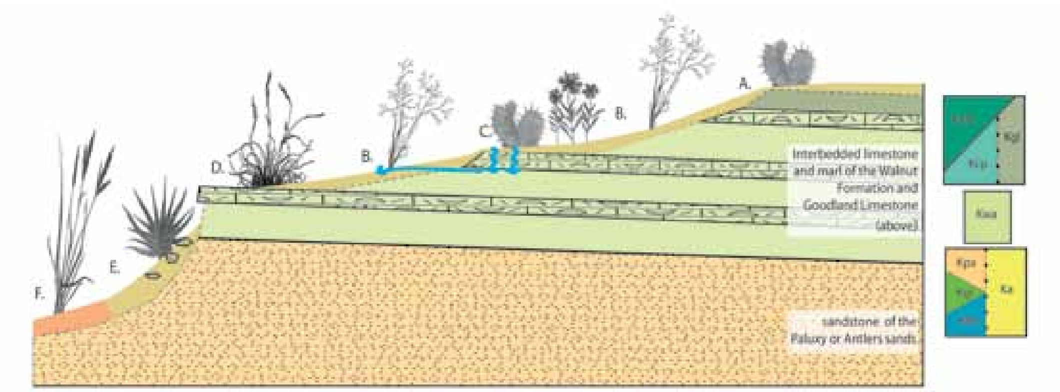

Fig. 2. A typical Walnut Formation landscape overlying Paluxy or Antlers sands and underlying Goodland Limestone showing the general stratigraphy of the Walnut Formation. Interbedded limestones and sands of the Fort Worth Prairie are distributed across North Central Texas. The Edwards (Ked), Comanche Peak (Kcp), or Goodland (Kgl) limestones overlay the Walnut Formation (Kwa). Their basal layer, at A, is a marl layer above the uppermost layer of Walnut Limestone where shallow soils formed over cracked limestone form barrens. Water flows vertically through limestone cracks until it hits an impermeable shale or marl layer, which forces lateral flow, causing water to seep out on the hillslope. Here, at B, soil is saturated through the spring and early summer. Soil dries out completely in late summer, supporting a habitat of hyperseasonal sedges, rushes, and grasses. At C, shallow soil, entisols and mollisols greater than 5 cm deep, forms over limestone creating barrens. This habitat is composed of geophytes, succulents, grasses, and forbs, which have very shallow roots or are able to persist in limestone cracks. At D, limestone is exposed, having no soil to very gravelly entisols less than 5 cm deep, forming a glade habitat. Sheet flow keeps soil from forming and thus vegetation is sparse. At E, the sandstone is not able to support the upper, more resistant layers and it begins eroding forming steep hillslopes. The marl then begins to slump and the lowest limestone shelf begins crumbling forming colluvial slopes of limestone topsoil overlying sandstone and causing an extension and mixing of calcareous and arenicolous species. At F, when the limestone topsoil is no longer present, sand species dominate, tall grasses can persist, and the post and blackjack oak forest begins, creating the Western Cross Timbers on Paluxy (Kpa) or Antlers (Ka) sands. Further south in the Edwards Plateau, the Walnut overlies the Glen Rose Limestone (Kgr). Please note, this is a diagram and is not drawn to scale.

between limestone layers vary in thickness and are easily penetrated by roots. The base of the Walnut consists of calcareous clays intercalated with cemented limestone (Hill 1901). The Goodland, Comanche Peak, and Edwards formations are paler and chalkier than the yellows and browns of the Walnut Formation, helping to distinguish them visually (Hill 1901).

The Walnut Formation developed through marine sedimentation in the Lower Cretaceous when the Gulf of Mexico spread inland, covering Texas. The Lower Cretaceous formations tend to be some of the largest regional formations, extending from mountainous boundaries in Oklahoma to Mexico. Deposited along belts through marine influence, the harder limestones alternate with clay and overlie sands, creating dip and cut plains as well as low escarpments carved by erosion (Hill 1901). To the east, younger geological layers are encountered on top of the Walnut, dipping eastward. These layers are eroded into gentle east-facing slopes, until a resistant limestone layer is exposed. Here a steep, west-facing slope is formed by rapid erosion of a less resistant layer below the harder cap, creating a cuesta topography with gentle plains sloping east and steep west-facing escarpments. The limestone layers make erosion resistant shelves connected by erodible slope-forming marl layers (Diggs et al. 1999; Dyksterhuis 1946; Hill 1901).

The Walnut Formation is unique in the contrasting lithification of its strata, which creates the diversity of modern habitats. There are deep clays, hard limestone glades, and shallow barrens soils derived from marls and fossil shell fragments. Seeps are also abundant on barrens and slopes, and they often interact with the underlying sands. Slope seeps frequently occur where water flows through fractured limestone and meets less permeable clay or less weathered massive limestone layers, creating a perched water table, causing water to flow laterally, and emerge as a seep where the stratum is exposed (Burgess and Busbey 2010, Llado 2011) (Fig. 2). Quaternary alluvial deposits over Paluxy Sandstone make up the bulk of soil parent materials in river valleys adjacent to upland Walnut exposures (Eifler 1993; McGowen et al. 1987; McGowen et al. 1991).

Site Description

The Red, Trinity, and Brazos rivers are the principle waterways, excluding lakes, that cross through the Walnut Formation. The Brazos is the southern boundary for the study site and the Red River the northern boundary. Several tributaries and headwater streams of the Trinity River run through the northern part of the Walnut exposures within the study area. For this research, the targeted area of the Walnut Formation lies between approximately 32.25° and 34°N and -97.25° and -98° W within the study area. The Walnut Formation extends much farther west and south beyond the borders of the study site (Fig. 1).

The area and elevation range of the Walnut Formation is difficult to calculate, as these data are not typical in geologic maps, and have not been found in any geological literature. Based on estimates, the area equates to around 390 sq km (McGowen et al. 1987). The elevation of collected vouchers ranges from a low of about 225 m in Tarrant County to a high of 435 m in Parker County.

Tarrant County receives an average of 86 cm of rainfall per year decreasing to the west and increasing to the east. The first freeze occurs around November 17 each year and the last freeze around March 15 (Alvarez & Plocheck 2011), yielding an average growing season of 249 days (National Oceanic and Atmospheric Administration 2012). The climate is described as humid subtropical with hot summers, having annually wide temperature variations and mild winters (National Oceanic and Atmospheric Administration 2012). The rainfall and temperature patterns during the duration of this study, yielded lower than normal rainfall, 51 to 56 cm, and 2011 was one of the hottest summers on record based on data from the KNFW weather station in southwest Fort Worth (National Climatic Data Center 2012).

METHODS

Vascular plants were collected on the Walnut Formation north of the Brazos River from January 2010 to June 2012, both on the formation and on slopes below Walnut outcrops, where colluvial deposits of marl and coquinite cover Paluxy and Antlers sands. Here the calcareous sediments interact with the sand, extending the range of the prairie limestone flora downslope into the Western Cross Timbers.

Maps from *The Geologic Atlas of Texas* identified approximate boundaries of the Walnut Formation. McGowen et al. (1987) covers the area north of the Brazos River in Parker, Tarrant, Johnson, and Hood counties. McGowen et al. (1991) covers Wise and Montague counties directly north; however, the Goodland and Walnut formations are undivided on this map. Tarrant, Parker, Wise, Johnson, and Hood counties contained the study sites, as no significant outcrops were known from Montague County.

Walnut Formation outcrops were verified using geologic maps and the presence of distinctive massive limestone strata with abundant *Texigryphaea*. First, potential sites were located using geologic maps, then publicly accessible areas were located. Since public parks spanned a broad north-south gradient, fewer private lands were surveyed. GIS maps were created showing the Walnut Formation overlaid with county streets to target stretches of road with high percentages of Walnut Outcrops.

Voucher herbarium specimens were collected using the “meander search” method (Hartman & Nelson 2008), in triplicate - when possible. If only one plant was present, a photographic voucher was taken to help preserve the population. Specimens were identified using *Shinners & Mahler’s Illustrated Flora of North Central Texas* (Diggs et al. 1999), which is the basis for nomenclature. *Flora of North America* and recent publications were also used (Estes & Small 2007; Kiger 2004; Nesom 2006; Smith et al. 2003) for identifications of species named or discovered in the area since 1999. Identifications were confirmed with herbarium specimens at the Botanical Research Institute of Texas (BRIT). Experts consulted include Bob O’Kennon, Barney Lipscomb, and Amanda Neill (BRIT). Specimen data include the date, soil type, habitat description, associated plants, species abundance, images of the plant and its habitat, locality, and GPS coordinates. References to protocol include Davis (1961), Diggs et al. (1999), Jennings et al. (2009), and Neill and Wilson (2000). Data and field images were imported into Atrium (BRIT Digital Herbarium 2012), an online biodiversity information system for public access. Specimens were archived in the BRIT Herbarium. Duplicates were shared with TEX/LL and TAES. The Fort Worth Nature Center and Refuge received the duplicates of specimens collected there, instead of TAES.

There were 835 collections from the North Central Texas Walnut Formation made by the authors. The BRIT Herbarium was consulted for other collections not included in the 835; thus all specimens cited are deposited at BRIT. The authors did not personally verify the exposed geologic stratum for all specimens collected by other botanists unless they were from specific sites or collecting events. Legacy collections, from BRIT, were included due to their presence on the Walnut Formation based on GPS coordinates and associated plant species. If Goodland Limestone was mapped within 200 m of the plants GPS location, the stratum the specimen was found upon was questionable and the collection omitted from the checklist.

A full checklist of the flora was created, and the flora was analyzed for rare or endemic taxa, invasive or potentially invasive species, and disjunct taxa. Relevé plots were completed for plant communities common to the Walnut Formation. Sites were subjectively selected based on local knowledge of representative sites and availability. Random site selection was avoided, as the objective was to define homogenous and repetitive plant communities in similar topographic, geological, and pedological contexts. This was done to confirm plant associations within and across geological formations, and to facilitate future comparisons (Jennings et al. 2004). Plots ranged in size and edges were avoided to reduce variability and to ensure the similarity of communities. Data collected for each plot includes GPS location, exposed geologic stratum, soil, hydrologic regime, slope, aspect, topographic position, percent cover and height class for each plant species present, and percent cover of non-vascular species and abiotic factors.

Plant communities were described as in Jennings et al. (2009). Associations are named using dominant and diagnostic taxa for each community. Taxa found within the same stratum are indicated by a hyphen, in different strata by a slash, and parenthetic notations indicate lower constancy or confidence. The order of species names indicates decreasing dominance (Jennings et al. 2009). No formal quantitative analysis on the relevé data was done; these associations are based largely on observation and constancy of dominant and diagnostic species. The authors believe many of the following communities are widespread enough to warrant tentative recognition in the Association Records database (NatureServe 2012b).

RESULTS AND DISCUSSION

Results of the study are included in the following sections: Major vegetational habitats, Comparison with the Walnut Formation South of the Brazos River; Unique Sites; Floristic Comparisons; Range Extensions, Invaders, Endemic Taxa; and Summary of Taxa.

MAJOR VEGETATIONAL HABITATS

While plant communities may not be mappable units as defined by the Ecological Society of America Vegetation Classification Panel (2011), these provisionally named associations are patterns that were consistently encountered throughout the North Central Texas Walnut Formation and could be studied further for consideration as recognized associations.

Plant communities aligned almost perfectly with geological and pedological boundaries. Soil depth and type were best indicated by vegetation structure and cover. As soil depth decreased, there was a strong correlation with light intensity as the canopy cover decreased (Fig. 3). The exception is weathered limestone with pockets of soil accumulation in deep crevices, allowing trees to take root and create a shady canopy as in a limestone scrub woodland.

While the Fort Worth Prairie was a mixed grass prairie in the 1940s, fire suppression and overgrazing converted it to a savannah (Fuhlendorf & Engle 2004; Mayer & Khalyani 2011). Shorter grasses dominate with decreasing soil depth. There are surges of annuals in the spring and fall coinciding with seasonal rains. Within the herb stratum, perennial forbs, annuals, and succulents dominate the spring, while herbaceous perennial bunchgrasses dominate the fall.

Due to the structural similarity of these habitats with limestone cedar glades in Alabama, Kentucky, and Tennessee, we follow the habitat designations described by Baskin and Baskin (1996, 2003) and Quarterman (1950a, 1950b, 1989). Glades are open areas of exposed Walnut Limestone with 0 to 5 cm soil. Here soil forms primarily in limestone cracks yielding patchy vegetation, typically less than 50 percent cover; though some

Fig. 3. Rhome, Texas site south of Highway 114, west of Highway 287: soil depth as it relates to light intensity in a typical Walnut Formation landscape. As soil depth increases over limestone bedrock, root depth increases. Shrubs and trees begin to establish themselves creating woodlands; here light intensity decreases, creating a refuge for sciophytes. The opposite is true on shallow soiled glades and barrens.

plants are capable of surviving in shallow soil over limestone. Barrens have slightly deeper soil, 5 to 25 cm over bedrock, and generally have more than 50 percent vegetative cover during the peak growing season. Seeps form on glades and barrens after cool-season rains when water pools and is unable to percolate through relatively impermeable limestone. Seeps also form on hillslopes when water infiltrates vertically through fractured limestone and reaches a less permeable clayey stratum, where it flows laterally and seeps out where the stratum is exposed on hillslopes. Glades, barrens, and seeps have low vegetation open to full sunlight, though occasionally mottes of *Juniperus* spp., *Quercus* spp., or *Rhus* spp. will form. Limestone scrub woodlands often occur on ridgetops above the contact with Paluxy or Antlers sand where instead of a glade, trees have taken root in cracks creating a refuge for sciophytes (Fig. 2).

Glades traditionally are composed of climax communities (Baskin & Baskin 2003; Jones 2005; Quarterman 1989) with cyclical changes in composition rather than directional changes. During a rainfall event, runoff or overland flow moves soil over nearly impermeable limestone, where it is deposited in cracks and removed from bare limestone, encouraging a glade habitat. Over time, soil accumulates in cracks and crevices and plants take root. Vegetation slows runoff, allowing soil to accumulate, and trees to take hold in the cracks, shifting the community dynamics. Removal of trees or drought can shift the community from mesic or woodland back to a glade (Quarterman 1989).

Glades, barrens, seeps, and limestone scrub woodlands form a rolling to scarped mosaic over Walnut Limestone that is unique to this area of North Central Texas, where most of the limestones are too chalky to form the erosion-resistant scarps or glade habitats. Our terminology differs from limestone cedar glade habitats in the southern Appalachians in that we use the term "Walnut Limestone Glade," though this is somewhat a misnomer because walnut trees do not dominate them as cedars do in the southeast; rather the Walnut Limestone is the geological stratum of the these habitats, the formation name having no relation to the dominant plants.

Glades:

Glades are quite extensive and are characteristic landscape features on the Walnut Formation. Glades are open areas of exposed limestone outcrops and rocky areas with soils around 0 to 5 cm deep. Texigryphaea fossil shell fragments usually dominate surfaces. The most common soils in Hood, Parker, and Tarrant counties are clayey upland paralithic entisols in the Maloterre Series (Colburn 1978; Greenwade et al. 1977; Ressel 1981). In Wise County, the Maloterre Series is not mapped and glades are shown to be associated with the Somervell or Venus Series, both mollisols (Ressel 1989), which, following field investigations, do not appear to be present on glades. The soils associated with glades in Wise County are very gravelly, shallow, undeveloped soils over limestone. They have no mollic epipedon and are likely entisols.

Glades are frequently found on ridge tops at the LBJ National Grasslands. Elsewhere glades are found next to incised stream channels or where large expanses of impermeable limestone are found near the surface below hillslopes. During storm events, impermeable limestone provides little to no infiltration of runoff, creating what is arguably infiltration excess (Hortonian) overland flow, thus preventing or slowing soil development.

Thus, glades are free of trees, except for occasional mottes, and shallow soils are incapable of retaining much water, thus plants are often succulent or extremely shallow rooted. Deep-rooted perennials establish their roots in limestone cracks; some probably extend roots to the marl, which has greater water holding potential. Glades are dominated by gravel or open soil, usually with less than 50 percent herbaceous coverage. The glades are a distinct habitat of specialized, often endemic plants. Few plants are weedy or characteristic of ruderal habitats.

***Aristida purpurea* var. *nealleyi*—*Erioneuron pilosum*—*Dalea* spp.—(*Lesquerella engelmannii*) Limestone Glade Herbaceous Vegetation Association.**—Dry glades tend to be present on ridgetops or upslope of glade seeps where the soil is well drained. Common perennial bunch grasses are *Aristida purpurea*, *Digitaria cognata, Erioneuron pilosum,* and *Tridens muticus*. *Limnodea arkansana* and *Vulpia octoflora* are the dominant cool season annual grasses, while *Sporobolus ozarkanus* is the dominant warm season annual grass. Other common components of dry glades include perennial herbaceous dicots such as *Dalea reverchonii, D. tenuis*, *Grindelia lanceolata, Lesquerella engelmannii, Paronychia virginica, Sida abutifolia,* scattered succulents including *Coryphantha sulcata, Escobaria missouriensis, E. vivipara, Opuntia phaeacantha,* and *Talinum calcaricum*, various non-vascular plants, and lichens.

Bouteloua curtipendula, Prunus rivularis, and *Schizachyrium scoparium* can be found in deep limestone crevices or on glade edges where the hillslope begins. As the glade thins, at the edge of the hillslope, the vegetation thickens. The species listed above are present in greater densities and *Asclepias asperula, Artemisia ludoviciana, Bouteloua curtipendula,* and *Liatris mucronata* may become dominant.

***Dalea reverchonii*—*Talinum calcaricum*—*Minuartia michauxii* Limestone Glade Herbaceous Vegetation Association.**—In less disturbed sites, this association occurs where soil has been thinned by erosion on the upslope side of a limestone expanse, or where shallow soil has started to accumulate on the downslope side of a glade. This interesting glade association is not locally extensive, but it is widespread among glades and may be more appropriately called a sub-association; however, when present the association is distinctive and recognizable on extremely shallow, clayey soils bordering expanses of bare limestone. *Nostoc commune*, *Sedum nuttallianum,* and *Sporobolus ozarkanus* are very common in these associations.

Barrens:

Glades are often surrounded by barrens or areas of locally thin soils, at least 5–25 cm deep, with small patches of exposed bedrock, rock fragments, and cryptogamic crusts. Barrens may also be on benches where there is more topographic relief; often they are interspersed with seeps. Dominated by bunch grasses, *Schizachyrium* *scoparium, Muhlenbergia reverchonii* (on wetter sites), *Aristida purpurea, Bouteloua pectinata, B. hirsuta*, and *Tridens muticus* are the typical species in this habitat; *Opuntia phaeacantha, Yucca pallida*, various herbaceous perennials, and cool-season and warm-season annuals are also present. Barrens have deeper soils incapable of supporting larger woody species; solitary trees are uncommon, but mottes of *Forestiera pubescens, Juniperus* spp., *Quercus fusiformis*, *Rhus* spp., and *Ulmus crassifolia* are common and provide a habitat for vines and sciophytes, thus supporting a unique microhabitat.

Opuntia phaeacantha tends to prefer drier upland barrens. *Schizachyrium scoparium* and *Yucca pallida* tend to occur on sloping, well-drained sites with good drainage and deeply weathered limestone or marl at the surface.

***Opuntia phaeacantha—Gaillardia pulchella—Liatris mucronata—(Tridens muticus)* Herbaceous Vegetation Association.—**Found on upland barrens with little to no slope, the association is quite common in shallow soil over limestone. Soils are usually paralithic entisols of the Maloterre Series or shallow, dark mollisols of the Aledo or Bolar Series. *Opuntia phaeacantha* and *Gaillardia pulchella* are common indicators occurring with various bunch grasses. *Liatris mucronata* and *Tridens muticus* are also both common components but vary in dominance. Typical perennial bunch grasses include *Aristida purpurea, Bouteloua rigidiseta, Nassella leucotricha,* and *Panicum oligosanthes. Nassella leucotricha* was not found in great abundance in 2010 and 2011, but following two of the hottest and driest summers on record, *N. leucotricha* was a more dominant member of this barrens community than *Tridens muticus*. Dominant annuals include *Bifora americana, Limnodea arkansana, Monarda citriodora, Plantago* spp., *Tetraneuris linearifolia,* and *Thelesperma filifolium. Bromus japonicus* is a successful invader of this habitat, outcompeting native grasses with exceptional success in wetter years, becoming the dominant species.

***Sporobolus compositus—Yucca pallida—Bouteloua* spp.—*Aristida purpurea* Herbaceous Vegetation Association.—**Found on mid to low slopes typically in marls, where the soil appears to be more clayey than typical Walnut loams, the soil is often mapped as Brackett, a paralithic inceptisol with an ochric epipedon; though in many cases it is probably parent material from the marl layer. Here, *Aristida purpurea* var. *nealleyi, Bouteloua hirsuta, B. pectinata, Sporobolus compositus,* and *Yucca pallida* dominate. This association is also typical on heavily weathered shelves just above the contact between the Walnut Formation and the underlying Paluxy or Antlers sands. *Asclepias asperula, Dalea hallii, Glandularia bipinnatifida, Hedyotis nigricans, Liatris aestivalis, L. mucronata, Marshallia caespitosa,* and *Pediomelum linearifolium* are common plants found in this association. *Schizachyrium scoparium* may be common, but is inconsistent. While still considered barrens, these communities frequently border seepy areas or woodlands dominated by *Quercus buckleyi* or *Fraxinus texensis*.

Muhly Seep (Hillslope and Limestone Glade Seeps):

Seeps are frequently found on hillslopes where water flows through fractured limestone, encounters an impervious shale layer, begins flowing horizontally, and seeps out on hillsides where the slope flattens for a few meters. Slopes are frequently dominated by *Muhlenbergia reverchonii*; Dyksterhuis (1946) called them Muhly Benches. Limestone Glade Seeps are often at the bottom edge of hillslope seeps, where water flowing downslope encounters impervious limestone and accumulates on a flat glade until it percolates through cracks or evaporates in summer heat. While saturated in the spring, these benches become arguably the most arid sites in the summer (Dyksterhuis 1946). The regime of alternative vernal saturation and serotinal desiccation is similar to hyperseasonal savannas described by Sarmiento (1984); thus the term 'hyperseasonal vernal seeps,' seems appropriate. Red oxidized root channels can be found in most seep soils, indicating seasonally hydric conditions.

Seeps are the primary location for riparian vegetation on the Walnut Formation. Many of these seeps feed into headwater streams of the Trinity River. While the species composition is somewhat different when comparing hillslope seeps with limestone glade seeps, the dominant species are generally the same.

***Muhlenbergia reverchonii—Eleocharis* spp.—*Carex microdonta*—(*Iva angustifolia*) Vernal Seep Herbaceous Vegetation Association.—**In Tarrant, Parker, and Hood counties, Muhly seeps are associated with the Aledo-Brackett-Maloterre Soil Association, and the Venus Series in Wise County. Following their namesake, *Muhlenbergia reverchonii* is usually a component of Muhly Seeps. Sedges such as *Eleocharis occulta*, *E. montevidensis*, and *Carex microdonta* may be co-dominant. *Allium* spp., *Isoëtes butleri,* and *Iva angustifolia* are also common seep components. *Carex microdonta* is typical on hillslope seeps but not on limestone glade seeps. *Tridens albescens* can be found on limestone glade seeps where water pools long enough to grow algal mats that form flaking calcareous crusts when dry; thus *T. albescens* appears to tolerate prolonged flooding better than *Muhlenbergia reverchonii.* The density of *M. reverchonii* is reduced where there is disturbance. Jue (2011) also noticed this on Duck Creek Limestone where *M. reverchonii* was absent from seeps near social trails or roadsides.

Eleocharis montevidensis is typical in seeps with deeper soil or standing water, whereas *E. occulta* inhabits glade seeps or drier edges, but these species often exist together. *Isoëtes butleri* is a common component on seeps that, when present, is dominant, though with its short growing season and reproductive material hidden underground, *I. butleri* is often overlooked as a seep component. *Rhynchospora nivea* may be locally dominant on hillslope seeps in the Paluxy or Antlers sandstones just downslope from contact with the Walnut Formation, in calcareous sandy clay loam.

Limestone Scrub Woodland:

Limestone scrub woodlands are generally found near ridge tops of north-facing slopes, often on Walnut Formation outcrops where soil is locally thin and detritus forms a significant duff layer. Tree roots are often anchored in large limestone cracks.

***Quercus buckleyi—Ulmus crassifolia—Celtis laevigata—Cercis canadensis—Fraxinus texensis* Scrub Woodland Association.—**Common trees include *Quercus buckleyi, Ulmus crassifolia, Celtis laevigata, Cercis canadensis,* and *Fraxinus texensis.* At some sites *Quercus sinuata* var. *breviloba* is present. *Quercus fusiformis* is also frequently present, though rarely dominant. Shrubs include *Ungnadia speciosa, Forestiera pubescens, Rhus trilobata,* and *Cornus drummondii.* Vines such as *Smilax bona-nox, Funastrum crispum, Vitis* spp., and *Ibervillea lindheimeri* are typical in these habitats. *Carex planostachys* is commonly the only bit of green plant mixed in with duff on the forest floor, except around forest edges where barrens are dominated by *Opuntia phaeacantha, Yucca pallida,* or *Schizachyrium scoparium.* The Ecological Society of America Vegetation Classification Panel (2011) has listed many similar associations in the Edwards Plateau Region of Texas and the Arbuckle Mountains of Oklahoma on mesa tops underlain by limestone, though the vegetation panel has not yet accepted many of these associations.

Headwater Streams and Xeroriparian Woodlands:

Headwater streams of the Trinity River are found throughout the Walnut Formation. Their hydrologic regimes are ephemeral to intermittent, with vernal flows and late-summer drought, which may be interrupted by short, high-flow episodes. These streams seem similar to uppermost Great Plains Prairie streams described by Dodds et al. (2004). The ridgetop starts are usually characterized by a prairie motte with a hillslope seep immediately downslope. The mottes are typically in a slight depression that collects runoff, resulting in a variable species assemblage including *Ambrosia ludoviciana, Andropogon gerardii, Celtis laevigata, Diospyros virginiana, Gleditsia triacanthos, Prunus rivularis*, and *Quercus fusiformis.* The motte abruptly stops downslope at the top of a headcut incision lined with seeps. Various grasses and *Carex microdonta* dominate the upper edge of the seep. As described above, the middle of a headwater hillslope seep is usually dominated by *Muhlenbergia reverchonii* and *Eleocharis occulta.* Seeps in eroding headwater stream slopes may also have *Panicum virgatum, Sorghastrum nutans,* and *Lythrum californicum.* The headwater stream channel at the footslope of seeps is characterized by seasonally hydrophytic species such as *Juncus texanus* and *Eleocharis montevidensis.* The soil is often gravelly with oxidized root channels in the surface layer. Downstream the erosional incision widens and an intermittently defined stream channel meanders along the floor. Small depressions hold water during late winter and spring, developing mats of filamentous algae and charophytes. Vegetation is usually herbaceous, though isolated clumps of shrubs and trees may occur. The side slope and width of the incision vary with bedrock, steeper and narrower in limestone, shallower and wider in marl. Similarly, stream sediments vary from coarse gravel to clay. Harder limestone strata create abrupt pouroffs where the plunging stream erodes softer rock beneath. Plants found here include *Ambrosia artemisiifolia, Aster ericoides, Eleocharis montevidensis, Helenium elegans, Isoëtes butleri, Iva angustifolia, Juncus interior, Juncus texanus,* and *Muhlenbergia reverchonii.* These open riparian habitats have a phenology adapted to hyperseasonal hydrology. Vernal saturation seems to prevent establishment of most cool-season annuals, though they are common on adjacent barrens. Spring dominants are perennial wetland species adapted to survive summer drought as rhizomes or small tubers, such as with *Juncus texanus, Eleocharis occulta,* and *E. montevidensis*. As seep flow declines during the onset of summer, the soil moisture regime shifts from hydric to mesic, and warm-season annuals, such as *Iva angustifolia* and *Ambrosia artemisiifolia,* establish on open ground. Late cool-season annuals may also establish, such as *Helenium elegans, Phalaris caroliniana,* and *Fuirena simplex.* Within the open riparian herbaceous vegetation there may be isolated clumps of *Cephalanthus occidentalis* and other shrubs or stunted trees, indicating access to subsurface summer moisture.

Headwater streams eventually reach downslope sites with deeper sediment or weathered sandstone. This transition is evident by an abrupt change to xeroriparian gallery forest or woodland. Xeroriparian areas on the Walnut Formation are small canyons that get increasingly deeper as the channel erodes Paluxy or Antlers sands. Stream channels usually are filled with alluvium, and surface flow is ephemeral or intermittent. The shallower canyons are characterized by *Celtis laevigata, Fraxinus texensis, Juniperus virginiana,* and *Ulmus crassifolia.* Here, when canyon walls are only a few meters high, the midstory has *Cornus drummondii, Prunus mexicana, Rhus glabra, Rhus trilobata, Sideroxylon lanuginosum,* and *Smilax bona-nox*, and the understory has *Andropogon gerardii, Elymus virginicus, Nasella leucotricha, Schizachyrium scoparium,* and *Sorghastrum nutans*. As the canyon deepens, the walls may be more than 4 m tall, and the gallery canopy is dominated by *Fraxinus texensis, Juniperus virginiana, Quercus buckleyi,* and *Ulmus americana*. The midstory has *Cercis canadensis, Frangula caroliniana, Smilax tamnoides, Toxicodendron radicans, Viburnum rufidulum,* and *Vitis* spp. The understory may include *Carex planostachys* and *Pellaea atropurpurea,* which root in alluvium and colluvium on the walls.

Mixed Grass Hillslope:
Mixed grass prairies are found on lower hillslopes and footslopes where the soil is deeper. Three of the "big four" tall grasses (*Andropogon gerardii, Schizachyrium scoparium,* and *Sorghastrum nutans*) are generally present, and *Panicum virgatum* is sometimes found on wetter sites. Often *Schizachyrium scoparium* is dominant, together with shorter grasses, especially *Bouteloua* spp., diverse forbs, small shrubs, and scattered trees. These footslopes are often Sunev Soils, mollisols that are deeper because the underlying geology is sand instead of limestone (Ressel 1981).

Roadsides and Lawns:
Roadsides and lawns provide a typical weedy flora. Common species include *Ambrosia trifida, Bothriochloa ischaemum* var. *songarica, Bromus catharticus, B. japonicus, Cynodon dactylon, Ipomoea cordatotriloba, Lamium amplexicaule, Medicago spp., Sherardia arvensis, Sisymbrium officinale,* and *Sorghum halepense.* Old home sites support persisting cultivated species such as *Iris germanica, Muscari neglecta, Nandina domestica,* and *Rosmarinus officinalis.*

COMPARISON WITH THE WALNUT FORMATION SOUTH OF THE BRAZOS RIVER

For the most part, similar habitats were observed north and south of the Brazos River. Though it is not within the scope of this paper to present a full comparison, a few trips were made to a Walnut Limestone site near Hico, Texas, and vouchers were collected. The most obvious difference in the flora of the southern Walnut Formation was the addition of many species that are more common in the Edwards Plateau region, for example *Melampodium leucanthum* and *Thelesperma simplicifolium*. Though uncommon, both of these species have been found elsewhere in North Central Texas, but were not collected on the northern Walnut Formation during this study.

Lyday's (1989) descriptions of plant associations of the Edwards, Walnut, and Glen Rose formations in Hays County, on the Edwards Plateau ca. 340 km south of Fort Worth, was used for a simple comparison of the northern and southern portions of the Walnut Formation. Hays County appears to have a very different species composition than the site outside of Hico, which is 266 km north of Hays County. Lyday (1989) found *Yucca rupicola, Rhus virens, Garrya ovata, Juglans major, Berberis trifoliolata,* and *Opuntia engelmannii* on the Walnut Formation in Hays County; these species were not documented on the northern portion of the Walnut Formation during this project, but some species may be present elsewhere locally. Notably, Lyday did not encounter *Quercus fusiformis* or *Ulmus crassifolia,* two dominants on the North Central Texas Walnut Formation, though he found them on adjacent formations, and found *Juniperus ashei* and *Quercus buckleyi* to be the dominant woody species on the Walnut Formation in Hays County. Much of this difference is likely derived from the different topographical context the Walnut Formation inhabits, valleys versus ridgetops, in the Lampasas Cut Plain and Edwards Plateau.

UNIQUE SITES

The major disturbances on the Walnut Formation are suburban development, cattle grazing, and quarrying. Most development is concentrated near Weatherford and Decatur, but urban sprawl continues north and west of Fort Worth. Most soils of the Walnut are too shallow to support crops, but ranching is common. The endemic *Dalea reverchonii* is not found where cattle graze (O'Kennon pers. comm.); thus it is found mostly on quarry sites or roadsides. These sites often have been scraped, creating an anthropogenic seral glade-like habitat, which is perfect for *D. reverchonii*. Quarried sites have a unique flora not typical of glades. These anthropogenic glade habitats have the same shallow soil, less than 5 cm deep, except open bedrock is usually covered with gravelly soil. The disturbance is evident by mounds of soil dividing glade habitats, as at the Utley Property in Weatherford, by a large portion of dug out ground that is about two feet lower than the adjacent landscape, with intermittent pools of water, as at the New Highland Property in Parker County.

Unit 70 of the LBJ National Grasslands supports a woodland on the gentle slope of the cuesta where water flowing off of the cuestas deposits soil giving it some alluvial properties. This depositional site contains *Carya illinoinensis* and *Maclura pomifera*, which were not found in any other habitat on the Walnut Formation.

The only accessible ephemeral stream directly on Walnut Limestone was found 0.66 km west-northwest of the intersection of Highway 287 and Highway 114 in Rhome. The stream runs underneath Highway 114 and provides a unique flora north and south of Highway 114. The site had one of the most diverse glade complexes; unfortunately a McDonald's and Loves gas station now sit on Goodland Limestone just upslope on the south side of the road. This construction altered the hydrology, and soil was dumped on the glade downslope with silt barriers between the soil and the ephemeral stream downslope from the glade, inhibiting the natural erosion processes that keep glades from forming soil. This site supported *D. reverchonii, Gratiola quartermaniae, Isoëtes butleri,* and *Talinum calcaricum*—all rarely collected in North Central Texas. This was the only site with *Briza minor, Callitriche heterophylla, Cardiospermum halicacabum, Justicia americana,* and *Xanthium strumarium;* though these can probably be found at other sites.

The New Highland Site, west-northwest of the intersection of New Highland and Highland Road near Springtown, is a quarry site on Walnut Limestone. Water accumulated here, forming a shallow pool or trough about 18 cm deep (on May 25, 2011) where the Walnut Limestone has been quarried about 3 m deep. The pool supported typical Walnut Seep vegetation, as well as some unique taxa not found at other sites, for example *Eleocharis palustris*. The dominant species found in the pool were *Eleocharis montevidensis, E. occulta, Iva angustifolia,* and *Tridens albescens*.

At a few sites, *Quercus stellata* (post oak) was found in alfisols on the Walnut Formation. Alfisols are mildly acidic sandy clays that are less fertile than mollisols. Their presence over limestone indicates that calcareous topsoil has leached over considerable time resulting in an ochric epipedon and an accumulation of clay nearer bedrock. *Quercus stellata* is generally only found on sandier soils in the East and West Cross Timbers.

FLORISTIC COMPARISONS

Unique floristic connections were found with Apacherian Savannas, formerly called desert grasslands, of Southwestern North America (Burgess 1995), and with Cedar Glades of the Southeast United States (Norton 2010). Though not an ecotone, the Walnut Formation exhibits distinct characteristics of Cedar Glades and

Apacherian Savannas, both structurally and floristically. Both the Apacherian Savannas and Cedar Glades contain edaphic communities that are strongly determined by soil and geology (Quarterman 1950a; Baskin & Baskin 2003; McAuliffe 1994).

A dry glade community found on limestone mesatops at LBJ National Grasslands, and occasionally on the upslope side of glade seeps where soil is well drained, consists of short grasses in shallow soil over limestone. This community resembles parts of the Apacherian Savannas in the Southwestern United States and Mexico, and contains *Coryphantha sulcata, Escobaria vivipara, Opuntia phaeacantha, Panicum hallii, Panicum obtusum, Tridens muticus,* and related species in *Bouteloua* and *Erioneuron*.

Cedar Glades of the Southeastern United States also have a great similarity structurally and floristically to the Walnut Glades. Cedar Glades are on limestone or dolomite from the Ordovician, Silurian, or Mississippian eras (Baskin & Baskin 2003). They are in lowland basins often surrounded and separated by rolling hills (Baskin & Baskin 2003; Norton 2010; Quarterman 1950a). Soils are lacking to very shallow and are deeper in crevices where the rock has cracked vertically (Quarterman 1950b). Annual grasses, perennial herbaceous dicots, mosses, *Nostoc commune,* and various lichens dominate limestone cedar glades (Baskin & Baskin 2003). *Juniperus virginiana* is the dominant shrubby vegetation surrounding the glades (Norton 2010; Quarterman 1950b).

The Walnut Glades and glade-like habitats west of the Mississippi River are not considered true Cedar Glades because they differ floristically (Norton 2010). Both habitats are hyperseasonal, with plants adapted to an extreme wet and extreme dry season (Norton 2010), thus having very different floristic aspects during the year. Dormancy mechanisms allow plants to persist through both saturation and drought (Quarterman 1950a). As with Cedar Glades, Walnut Glades all have a slightly different species composition due to geographical and structural variations (Baskin & Baskin 1996). Many species on Walnut Glades are also found on Cedar Glades, such as *Croton monanthogynus, Panicum acuminatum, Gratiola quartermaniae, Hedyotis nigricans, Heliotropium tenellum, Isoëtes butleri, Juncus filipendulus, Nostoc commune, Nothoscordum bivalve, Oenothera macrocarpa, Talinum calcaricum,* and *Sporobolus vaginiflorus s.l.*. Related species include *Manfreda virginica* in Cedar Glades versus *Yucca pallida* on the Walnut Formation, *Opuntia humifusa* versus O. *phaeacantha*, *Dalea gattengeri* versus *D. reverchonii* and *D. tenuis, Eleocharis bifida* versus *E. occulta* and *E. montevidensis, Minuartia patula* versus *M. michauxii,* and *Sedum pulchellum* versus *S. nuttallianum* (Jones 2005; Quarterman 1950b; Norton 2010; Baskin & Baskin 2003).

George (1987) did a brief comparison between eastern Cedar Glades and the Weches Formation in East Texas. The Weches is a limestone that is floristically isolated because it is surrounded by sand and arenicolous species. The Weches Formation receives annual precipitation similar to that of limestone cedar glades in the Southeastern United States. George (1987) found shared species between the Weches formation and limestone cedar glades, the most notable being *Leavenworthia texana* and *Sedum pulchellum*. *Leavenworthia texana,* the only species of the genus in Texas, is endemic to deep East Texas; however, its relatives are dominant on Limestone cedar glades, mapped by Baskin and Baskin (2003). *Sedum pulchellum* is more widespread but is not found farther west than East Texas. It appears that the Weches Formation and the Ozark glades could serve as a bridging habitat between eastern limestone cedar glades and Walnut Limestone glades.

RANGE EXTENSIONS, INVADERS, AND ENDEMIC TAXA

A species was denoted as exotic and invasive using the Texas Invasives database (Texas Invasives 2012). The harsh dry conditions of glades and barrens discourage invasives, though they are common on roadsides, in old pastures, and in disturbed seeps and barrens. In barrens and roadsides, *Bromus catharticus*, *Bromus japonicus*, *Bromus tectorum,* and *Bothriochloa ischaemum* var. *songarica* are common competitors with the native prairie grasses; among these *Bromus japonicus* was the most problematic on the barrens. *Sorghum halepense* was found at two sites in seeps, at the Utley Prairie, and at intermittent streams near the roadside in Rhome where water was plentiful; however, it was a dominant on roadsides. *Arundo donax* was found at one site (New Highland) in a very disturbed quarry near a deer blind. *Carduus nutans* ssp. *macrocephalus* was found as a roadside weed at only one site in Weatherford and has since been removed by the property owner. *Ligustrum quihoui* was common on barrens at the Fort Worth Nature Center and Refuge in the understory replacing *Forestiera pubescens* and *Rhus trilobata*, but uncommon elsewhere on the Walnut Formation. *Nandina domestica* was found only at the Fort Worth Nature Center and Refuge in a riparian canyon and at an old home site. *Vitex agnus-castus* was found only at the Eagle Mountain Lake Park, with other persisting homestead plants such as *Lantana camara* and *Jasminum floridum*.

Two seep dwellers were found new to North Central Texas during this study. *Gratiola quartermaniae* is endemic to rock outcrops in Tennessee, Alabama, and Central Texas (Estes & Small 2007), but was found commonly in limestone glade seeps in North Central Texas (Taylor & O'Kennon, in prep). *Isoëtes melanopoda* is the only species of the genus listed in North Central Texas (Diggs et al. 1999), but scanning electron microscopy of spores revealed that *I. butleri* is actually prevalent in North Central Texas. *Isoëtes butleri* was known previously only from the Edwards Plateau in Texas and elsewhere in the United States is locally common on limestone (Taylor et al. 2012). *Talinum calcaricum*, now *Phemeranthus calcaricus*, but referred to as *Talinum calcaricum* in this paper for nomenclatural consistency, previously thought to be endemic to limestone cedar glades in Alabama, Kentucky, and Tennessee, was found new to Texas during this study (Swadek 2012).

Texas and Oklahoma regional endemics found on the Walnut Formation are *Asclepias linearis, Carex perdentata, Dalea hallii, D. reverchonii, D. tenuis, Fraxinus texensis, Ibervillea lindheimeri, Juncus texanus, Liatris aestivalis, Lupinus texensis, Oenothera coryi, Pediomelum cyphocalyx, P. hypogaeum* var. *scaposa, Pediomelum latestipulatum, Pediomelum reverchonii, Silphium albiflorum, Tradescantia humilis,* and *Yucca pallida* (Diggs et al. 1999). *Muhlenbergia reverchonii* is not listed as endemic in literature but is only known from limestone seeps in Texas and Oklahoma (Barkworth et al. 2007); it is not clear whether the distribution of *M. reverchonii* might be more widespread. *Eleocharis occulta* (Smith et al. 2003) and *Liatris aestivalis* (Nesom & O'Kennon 2001) were also collected on the Walnut Formation and are endemic to the region. A distinction between strict nativity to Texas was ignored, as the Walnut Formation extends into southern Oklahoma, and political boundaries do not correspond with regional vegetation.

Dalea reverchonii is endemic to North Central Texas with a very limited range, only found in Hood, Parker, and Wise counties on glades and barrens of the Walnut Formation, the exception being the type location in Edwards Limestone on the butte of Comanche Peak in Hood County. It is listed as imperiled by Nature Serve (2012a) and of conservation concern (Diggs et al. 1999).

According to NatureServe (2012a), *D. reverchonii* has been extirpated from the top of Comanche Peak and it grows in "grasslands or openings in post oak woodlands on shallow calcareous clay to sandy clay soils over limestone. Often among sparse vegetation in barren, exposed sites." This is inaccurate. Multiple status reports (Mahler 1984; McLemore & O'Kennon 2003; O'Kennon 2010) indicate that *D. reverchonii* occurs atop Comanche Peak; however, these status reports have not been formally published. Voucher specimens of *D. reverchonii* atop Comanche Peak exist at BRIT (*O'Kennon 23370; 18793* Texas: Hood County), and two type specimens are at the Missouri Botanical Garden (*Reverchon 1273* Texas: Hood County) found on "rocks. Top of the Comanche Peak" in June of 1882; the isotype is at BRIT.

The type population on Comanche Peak, visited in May 2011, is on Edwards Limestone and is the only known occurrence of *Dalea reverchonii* not on Walnut Limestone. This population of *D. reverchonii* is found on the sloping ridgetop edge of the Comanche Peak butte on a glade of Edwards Limestone just above the contact with Comanche Peak Limestone.

Dalea reverchonii is restricted to glade and barren habitats, able to thrive with its taproot wedged deep in limestone cracks. Most commonly, it is found in glade habitats with no soil, or shallow soil, which is covered by gravel from Walnut Limestone, but it is not found in post oak wood openings, contradictory to NatureServe (2012a). It is often associated with *Nostoc commune*, a nitrogen fixing cyanobacterium, and various cryptogamic crusts, together with *Aristida purpurea* var. *nealleyi, Minuartia michauxii, Talinum calcaricum*, *Plantago helleri*, and *Tetraneuris linearifolia*.

As previously stated, *Dalea reverchonii* appears to thrive in sites that have been quarried, leaving behind suitable anthropogenic glades. Free from cattle grazing, these old quarries are habitat for *D. reverchonii*. Though a rare species in North Central Texas due to its restricted range, existing populations tend to support many individuals. *Dalea reverchonii* can occur under episodic disturbance on Walnut Limestone, even surviving an asphalt application.

Table 1. Distributional summary of the North Central Texas Walnut Formation vegetation.

List by taxonomic category	Families	Genera	Species	Taxa	List by special category	Taxa
Ferns	1	1	1	1	Introduced Taxa to NA	59
Fern Allies	1	1	1	1	Exotic Invasive Taxa	12
Gymnosperms	1	1	3	3	Texas Endemic Taxa	14
Dicots	66	217	329	337	Regional Endemics	6
Monocots	10	66	118	125	Species of Concern	1
Total	79	286	452	467	State Records	1

SUMMARY OF TAXA

The flora consists of 467 infraspecific taxa, 452 species in 286 genera and 79 families. There are 61 introduced species. The richest five plant families are Asteraceae (74 taxa), Poaceae (73), Fabaceae (34), Euphorbiaceae (18), and Cyperaceae (17) (Table 1). Fifteen habitat types were recognized on the Walnut Formation. Few species are ubiquitous across multiple habitats; most species are locally adapted to one particular habitat within the Walnut Formation.

APPLICATIONS AND FURTHER RESEARCH

Floristic Studies

The Walnut Flora, as any other, is never truly static. Additional collections from different habitat types would be valuable additions. The proposed vegetation associations are provisional and should be verified with more quantitative analysis of plot data, in conjunction with soil profile descriptions.

As the southern portion of the Walnut Formation was not thoroughly sampled, a focused study of the area is essential for understanding the Walnut Formation landscape. This would be especially valuable as Hill (1901) described the part of the Walnut Formation found in the Lampasas Cut Plain as the Walnut Prairie, and the most representative portion of the Walnut Formation.

As mentioned, some Walnut Formation vegetation does not appear to align with other Grand Prairie or Fort Worth Prairie limestone formations and better understanding of this ecoregion would emerge from an in-depth comparison of the Comanche Peak, Denton, Duck Creek, Edwards, Fort Worth, Glen Rose, Goodland, Kiamichi, Main Street, and Weno Formations.

Muhly Seeps as Wetlands

Jue (2011) and Llado (2011) studied Muhly Seeps on the Fort Worth Prairie on Duck Creek Limestone. Their objective was to see if the vegetation, soils, and hydrology would classify Muhly Seeps as wetlands using United States Army Corps of Engineers (USACE) 404 permitting criteria. Unfortunately their studies were performed in a drought year, so neither the vegetation nor hydrology aligned closely enough with USACE requirements for wetland status. These requirements state that given a 280-day growing season, soils must be saturated for 12.5% of the growing season meaning 35 days of saturation are required to meet the hydrology criterion (United States Army Corps of Engineers 1987). While Llado and Jue's study site did not yield these results, a few seeps near Rhome, Texas and at the Eidson Property near the Fort Worth Nature Center and Refuge showed hydric soil properties of gleyed color and a hydrogen sulfide odor through June in dryer years. More Muhly Seep sites should be monitored for possible wetland status of these unique habitats.

Cedar Invasion

The increasing presence of *Juniperus* spp. (cedars) in North Central Texas provides an interesting potential for study. Frequently quite invasive in grasslands, cedars were not mentioned at all in historic North Central Texas literature (Hill 1901, Bray 1906, Dyksterhuis 1946). It is well understood in the region that *Juniperus* spp. have extended their ranges in response to fire suppression, allowing *Juniperus* to overtake many landscapes in under 65 years. Eventually habitat expansion of the three species of *Juniperus* in North Central Texas (*J. virginiana, J. ashei,* and *J. pinchotii*) may make Walnut Glades more comparable to eastern Cedar Glades.

Comparisons with Eastern Limestone Cedar Glades

Cedar Glades and similar outcrops in Texas could be compared using similar sampling methods as described in Norton (2010) and George (1987). *Nostoc commune,* an important nitrogen fixing cyanobacterium in Cedar Glades, is also quite abundant in Walnut Limestone glades. When comparing these different habitats, the non-vascular flora should also be considered, as it is a major component of habitats (Quarterman 1950b) and cryptogams are important to soil properties (Dunne 1989).

Landscape Design Applications

Williams (2008) and Kinder (2009) used the Fort Worth Prairie, including Walnut Limestone barrens, as a model for green roof design in North Central Texas through biomimicry of natural systems. Shallow limestone barrens, like those of the Fort Worth prairie, are ideal study sites for green roof research because of the plants' ability to survive in soils less than 15 cm deep. Soil depth is important when taking into account the amount of weight a roof can hold. Williams' (2008) and Kinder's (2009) research proposes using native plants and soil—for bacteria, fungi, and the seed bank in the soil—to construct green spaces in urban areas; thus an improved knowledge of the ecology of the Fort Worth Prairie will be a valuable basis for appropriate designs.

Biomimicry has also been proposed for design and implementation of rain gardens or bioswales, along with other storm water management and water-purifying features. In Texas, rain gardens need to survive without year-round water; they must be adapted to seasonal rains and very hot, dry summers. Hyperseasonal seeps and headwater stream riparian vegetation, as described in this investigation, could serve as a native habitat design template.

CONCLUSIONS

The Walnut Formation provides the context for unique habitats and plant communities in North Central Texas. Stratigraphy and landform have large influences on plant communities. Hard limestone strata alternate with softer, clayey sediments, eroding into landscapes forming characteristic glades, barrens, and seeps. The plant communities of these habitats combine elements of prairie and Edwards Plateau vegetation with endemic and disjunct species, indicating a long history of accumulation and adaptation in the unstable climate of the Southern Plains. The vegetation is clearly associated with the Fort Worth Prairie Ecoregion, yet unique within it. The limestone glade association with *Dalea reverchonii, Talinum calcaricum,* and *Minuartia michauxii* is the most distinctive. Hyperseasonal vernal seeps and headwater stream habitats are not typical wetlands, nor are they truly prairie grassland. These riparian communities can be found in other parts of the Fort Worth Prairie, yet they seem especially prominent in Walnut Formation landscapes. Connections with the adjacent Western Cross Timbers are evident, with *Quercus stellata* woodlands on ridgetop alfisols, xeroriparian canyons leading into Cross Timbers riparian forest, and footslope calcareous sandy soils where Prairie and Cross Timbers species mix in diverse combinations. Thus the Walnut Formation supports considerable local biodiversity.

Two species new to North Central Texas: *Gratiola quartermaniae* (Taylor & O'Kennon in prep.) and *Isoëtes butleri* (Taylor et al. 2012) were discovered during this project. *Talinum calcaricum* was found new to Texas (Swadek 2012).

The need to further explore the ecology of North Central Texas is becoming more apparent and necessary. As the Metroplex expands, the population grows, and climate change continues, the connection to place and natural history will become more important to quality of life. Using a geological context for a floristic survey offers insights that would be less evident in county-based floras.

ANNOTATED CHECKLIST

Vascular plant families are alphabetically arranged within major groups. Angiosperm families are subdivided into Magnoliopsida (Dicots) and Liliopsida (Monocots). Taxa are listed alphabetically within their respective families by genus, species, and subspecific epithet. Authorities are given for all taxa and common names follow the scientific names. Common names and authorities follow Diggs et al. (1999); if a common name is lacking, one was not indicated in Diggs et al. (1999). For species discovered following 1999, nomenclature follows their representative publications (Estes & Small 2007; Nesom 2006; Smith et al. 2003) Next is the collector abbreviation and number, followed by the abbreviation of the major vegetational habitat in which the taxon was collected, and a special symbol if applicable. Species introduced to North America, regional and Texas endemics, and conservation concerns follow Diggs et al. (1999) and exotic and invasive taxa follow the Texas Invasives Database (2012).

Habitat type:

AQ aquatic—emergent, floating, submerged
B barren
DG dry glade
EH eroding hillslope
GS glade seep
HWS headwater stream
HS hillslope seep
L lawn
LSW limestone scrub woodland
MGH mixed grass hillslope
P pond edge
R roadside
SW Sand formation—Walnut Formation contact
W woodland
XR xeroriparian woodland

Symbols by category following Taxon:

introduced to North America
⊘ exotic and invasive in Texas (Texas Invasives Database 2012)
TX endemic
regional endemic
⚠ conservation concern
! State record

Collectors:

S R.K. Swadek
ROK R.J. O'Kennon
KRN K.R. Norton
SRK S.R. Kieschnick
TFF T.F. Franklin
JQ Jeff Quayle
ELB E.L. Bridges
WVM Will and Valerie McClatchey

LYCOPODIOPHYTA

Isoëtaceae

Isoëtes butleri Engelm., Butler's quillwort S 201 GS; S 871 HS; S 917 GS; S 1238 HS/HWS

POLYPODIOPHYTA

Pteridaceae

Pellaea atropurpurea (L.) Link, cliff-brake S 743 XR; S 1254 XR; KRN 883

PINOPHYTA

Cupressaceae

Juniperus ashei J. Buchholz, mountain cedar S 706 B; S 788 B
Juniperus pinchotii Sudw., red-berry juniper S 723 B
Juniperus virginiana L., eastern red-cedar S 236 B; S 527 HS/SW

MAGNOLIOPHYTA: MAGNOLIOPSIDA

Acanthaceae

Dyschoriste linearis Torr. & A. Gray, narrow-leaf snakeherb S 310 DG; S 584 DG/R; S 1051 DG; S 1107 B
Justicia americana (L.) Vahl, American water-willow S 261 AQ/GS; S 1048 AQ/GS
Ruellia humilis Nutt., prairie petunia S 373 B; S 392 HS; S 398 EH; S 744 XR

Amaranthaceae

Amaranthus blitoides S. Watson, prostrate pigweed S 780 W
Amaranthus retroflexus L., red-root pigweed WVM 261
Amaranthus rudis J.D. Sauer, water-hemp S 756 P

Anacardiaceae

Rhus glabra L., smooth sumac S 281 B; S 402 EH
Rhus lanceolata (A. Gray) Britton, prairie sumac S 704 B
Rhus trilobata Nutt., skunkbush S 227 B; S 926 LSW; WVM 28; WVM 143
Toxicodendron radicans (L.) Kuntze, poison-ivy WVM 134; WVM 180
Toxicodendron radicans (L.) Kuntze ssp. *verrucosum* (Scheele) Gillis, poison-ivy S 630 LSW

Apiaceae

Ammoselinum butleri (Engelm. ex S. Watson) J.M. Coult. & Rose, Butler's sand-parsley S 216 GS
Bifora americana Benth. & Hook. f. ex S.Watson, prairie bishop S 177 B; S 269 GS; S 334 HS; S 1044 B; S 1090 B; S 1106 B; S 1113 LSW; KRN 758 B; KRN 888
Chaerophyllum tainturieri Hook. var. *dasycarpum* Hook. ex S. Watson, hairy-fruit chervil S 180 WS
Chaerophyllum tainturieri Hook. var. *tainturieri,* S 1061 DG
Cymopteris macrorhizus Buckley, big-root wavewing S 823 B
Daucus pusillus Michx., rattle-snake weed S 271 GS; S 1076 B; S 1092 B
Eryngium leavenworthii Torr. & A. Gray, Leavenworth's eryngo S 430 EH
Polytaenia nuttallii DC., prairie parsley S 629 B; S 1041 HS
Spermolepis inermis (Nutt. ex DC.) Mathias & Constance, spreading scaleseed S 896 B; S 1104 B
Torilis arvensis (Huds.) Link, beggar's lice S 270 GS; S 1047 GS; WVM 57

Apocynaceae

Amsonia ciliata Walter var. *texana* (A. Gray) J.M. Coult., Texas slimpod S 152 B; S 875 B; TFR 219 B
Apocynum cannabinum L., Indian-hemp S 1078 XR

Aquifoliaceae

Ilex decidua Walter, possumhaw S 119 EH; S 797 P; WVM 14; WVM 68; WVM 69

Asclepiadaceae

Asclepias asperula (Decne.) Woodson ssp. *capricornu* (Woodson) Woodson, antelope-horns S 174 B; S 891 DG; S 1102 B; S 1123 B
Asclepias engelmanniana Woodson, Engelmann's milkweed KRN 924
Asclepias linearis Scheele, slim milkweed S 713 MGH/SW

Asclepias stenophylla A. Gray, slim-leaf milkweed S 411 EH
Asclepias verticillata L., whorled milkweed S 415 LSW/SW
Asclepias viridiflora Raf., green-flower milkweed S 413 EH; S 712 EH/SW; S 1248 B
Asclepias viridis Walter, green milkweed S 331 HS; S 617 R; S 1075 B
Funastrum crispum (Benth.) Schltr., wavy leaf milkweed vine S 633 LSW; S 638 B; TFR 218 LSW
Matelea biflora (Raf.) Woodson, two-flower milkvine S 591 B

Asteraceae
Achillea millefolium L., common yarrow S 763 W; S 1240 B
Ambrosia artemisiifolia L., common ragweed S 480 B
Ambrosia confertiflora DC., WVM 276
Ambrosia psilostachya DC., western ragweed S 441 R; S 526 HS/SW
Ambrosia trifida L. var. *texana* Scheele, blood ragweed S 755 P; S 783 R
Arnoglossum plantagineum Raf., prairie-plantain S 1251 XR
Artemisia ludoviciana Nutt. ssp. *mexicana* (Willd. ex Spreng) D. D. Keck, Mexican sagebrush S 445 DG; S 514 MGH/SW; S 764 W; S 772 DG
Aster ericoides L., heath aster S 482 B; S 487 B; S 519 MGH/SW
Aster praealtus Poir., willow-leaf aster S 759 P
Aster pratensis Raf., silky aster ROK 20719 GS
Aster subulatus Michx. var. *ligulatus* Shinners, wireweed S 531 HS
Baccharis neglecta Britton, Roosevelt-weed S 912 HS/SW
Baccharis texana (Torr. & A. Gray) A. Gray, prairie baccharis S 509 DG; S 790 B
Brickellia eupatorioides (L.) Shinners, S 775 W; S 778 W; S 787 R; WVM 270
Carduus nutans L. ssp. *macrocephalus* (Desf.) Nyman, nodding-thistle S 223 B
Carduus tenuiflorus Curtis, slender bristle-thistle WVM 12
Centaurea americana Nutt., basket-flower S 282 B
Cirsium texanum Buckley, Texas thistle S 237 B; S 614 B
Cirsium undulatum (Nutt.) Spreng., wavy-leaf thistle S 1103 B
Chaetopappa asteroides Nutt. ex DC., common least daisy S 827 G; S 858 B
Conyza canadensis (L.) Cronquist var. *glabrata* (A. Gray) Cronquist, S 419 GS
Dracopis amplexicaulis (Vahl) Cass, clasping coneflower S 279 B; S 1040 GS
Dysodiopsis tagetoides Torr. & A. Gray, marigold dogweed S 332 HS; S 404 EH; KRN 877
Echinacea angustifolia DC., blacksamson S 182 EH; S 414 LSW/SW; S 731 EH/SW; S 909 B; S 1071 EH/SW
Echinacea atrorubens Nutt., KRN 776 RRR
Engelmannia peristenia (Raf.) Goodman & C.A. Lawson, Engelmann's daisy S 287 HS; S 348 R; S 893 DG
Erigeron strigosus Muhl. ex Willd var. *strigosus*, prairie fleabane S 181 EH; S 657 HS; S 1245b XR; ROK 12153 G; ROK 12154 G; ROK 12157 B
Eupatorium serotinum Michx., fall boneset S 720 HS/SW
Evax prolifera Nutt. ex DC., rabbit tobacco S 159 B; S 884 DG; S 901 DG
Evax verna Raf. many-stem evax S 848 B
Gaillardia aestivalis Walter var. *aestivalis*, yellow Indian blanket S 319 SW; S 729 EH/SW
Gaillardia aestivalis (Walter) H.Rock var. *flavovirens* (C. Mohr) Cronquist, yellow Indian blanket S 658 HS
Gaillardia pulchella Foug., Indian-blanket S 192 R/DG; S 1046 GS; S 1086 B; S 1099 B
Grindelia adenodonta (Steyerm.) G.L.Nesom, little-head gumweed ROK 22675 R
Grindelia lanceolata Nutt., gulf gumweed S 378 DG; S 709 DG; S 773 DG; KRN 929
Grindelia nuda A. W. Wood, rayless gumweed S 496 DG
Gutierrezia dracunculoides (DC.) S. F. Blake, common broomweed S 431 EH/R; S 454 DG; S 476 B; S 1140 DG
Helenium elegans DC., sneezeweed S 420 GS; S 702 GS; S 1239 HS/HWS; KRN 887
Helianthus annuus L., common sunflower S 424 B
Helianthus maximiliani Schrad., Maximilian sunflower S 467 HS/SW
Heterotheca canescens (DC.) Shinners, gray-gold aster SRK 323 R
Hymenopappus scabiosaeus L'Hér var. *corymbosus* (Torr. & A. Gray) B.L. Turner, old plainsman S 186 EH
Hymenopappus tenuifolius Pursh, old plainsman S 175 B; S 622 EH; S 851 B; WVM 11
Iva angustifolia Nutt. ex DC., marsh-elder S 753 GS; S 792 GS
Lactuca canadensis L., wild lettuce S 395 R
Lactuca ludoviciana (Nutt.) Riddell, western wild lettuce S 639 B
Lactuca serriola L., prickly lettuce WVM 252 III
Liatris aestivalis G.L. Nesom & O'Kennon, summer gayfeather S 365 EH; S 405 EH; S 732 EH/SW RRR
Liatris mucronata DC, narrow-leaf gayfeather S 459 MGH; S 478 B; S 510 EH; S 511 MGH/SW
Lindheimera texana Engelm. & A. Gray, Texas-star S 212 B; S 923 B; S 1100 B
Lygodesmia texana Torr. & A. Gray, Texas skeleton-plant S 314 B; S 1098 B
Marshallia caespitosa Nutt. ex DC. var. caespitosa, Barbara's buttons S 257 EH; KRN 773 DG
Palafoxia callosa (Nutt.) Torr. A. Gray, small palafoxia S 425 B; S 439 DG; S 483 B; SRK 322 R
Parthenium hysterophorus L., false ragweed S 710 W; S 779 W
Pyrrhopappus grandiflorus (Nutt.) Nutt., tuber false dandelion S 197 R/DG
Pyrrhopappus pauciflorus (D. Don) DC., mini-stem false dandelion S 264 GS; S 579 GS; S 1037 GS
Ratibida columnifera (Nutt.) Wooton & Standl., Mexican-hat S 313 B
Rudbeckia grandiflora (D. Don) J.F. Gmel. ex DC. var. *alismifolia* (Torr. & A. Gray) Cronquist, rough coneflower S 391 HS
Rudbeckia hirta L. var. *pulcherrima* Farw., black-eyed Susan S 349 R/DG
Silphium albiflorum A. Gray, white rosinweed S 325 B; S 360 B; KRN 925; KRN 928
Silphium laciniatum L., compass-plant KRN 926
Silphium radula Nutt., rough-stem rosinweed S 393 HS
Solidago nemoralis Aiton var. *longipetiolata* (Mack. & Bush) E. J. Palmer & Steyerm., S 463 MGH/SW
Solidago nitida Torr. & A. Gray, shiny goldenrod S 794 GS
Solidago radula Nutt., rough goldenrod S 522 HS/SW
Solidago rigida L., stiff goldenrod S 513 MGH/SW; S 784 R
Sonchus oleraceus L., common sow-thistle S 253 GS
Taraxacum officinale L., dandelion WVM 4 L
Tetraneuris linearifolia (Hook.) Greene, S 651 B; S 172 HS; S 846 B; S 890 DG; ELB 13633
Tetraneuris scaposa (DC.) Greene, plains yellow daisy S 138 EH; S 145 GS; S 183 EH; S 899 DG; WVM 8; WVM 29; KRN 665
Thelesperma filifolium (Hook.) A. Gray var. *filifolium*, greenthread S 157 B; S 1045 GS; S 1088 B; S 1124 B
Vernonia baldwinii Torr., Baldwin's ironweed S 418 R
Xanthisma texana DC. ssp. *drummondii* (Torr. & A. Gray) Semple, Texas sleepy daisy S 624 DG; S 1137 DG
Xanthium strumarium L. var. *canadense* (Mill.) Torr. & A. Gray, cocklebur S 758 P

Berberidaceae
Nandina domestica Thunb., sacred-bamboo S 742 XR; WVM 47

Boraginaceae
Buglossoides arvensis (L.) I.M. Jonst. S 819 EH/SW

Heliotropium tenellum (Nutt.) Torr., pasture heliotrope S 375 B; S 381 DG; S 474 B
Lithospermum incisum Lehm., narrow-leaf gromwell S 163 EH; S 852 B; S 908 B

Brassicaceae
Capsella bursa-pastoris (L.) Medik., shepherd's-purse S 572 L; WVM 3; WVM 147
Draba cuneifolia Nutt. ex Torr. & A. Gray, wedge-leaf draba S 126 B; S 821 B; WVM 25; WVM 24; WVM 32
Lepidium austrinum Small, southern pepperweed S 242 B; S 895 DG
Lepidium virginicum L., Virginia pepper-grass S 855 B
Lesquerella gordonii (A. Gray) S. Watson, popweed S 559 B
Lesquerella engelmannii (A. Gray) S. Watson, Engelmann's bladderpod S 161 EH; S 162 EH; S 198 R/DG; S 587 DG; S 693 DG; S 882 DG
Sisymbrium officinale (L.) Scop., hedge-mustard S 898 R

Cactaceae
Coryphantha sulcata (Engelm.) Britton & Rose, pineapple cactus S 201 R/DG; S 696 DG
Echinocereus reichenbachii (Terscheck ex Walp.) F. Haage, hedgehog cactus S 636 LSW; KRN 784 DG
Escobaria missouriensis (Sweet) D.R. Hunt var. *robustior* (Engelm.) D.R. Hunt, plains nipple cactus S 207 DG
Escobaria vivipara (Nutt.) Buxb., spiny-star S 434 DG; S 697 DG
Opuntia phaeacantha Engelm. var. *major* Engelm., prickly-pear S 350 DG; S 359 B; S 628 B; S 766 W; S 1085 B

Callitrichaceae
Callitriche heterophylla Pursh., larger waterwort S 293 AQ/GS

Campanulaceae
Triodanis leptocarpa (Nutt.) Nieuwl., slimpod Venus' looking-glass S 194 R/DG

Capparaceae
Polanisia dodecandra (L.) DC, clammyweed S 426 B/R

Caprifoliaceae
Lonicera albiflora Torr. & A. Gray, white honeysuckle S 160 B; S 403 EH
Symphoricarpos orbiculatus Moench, coralberry S 497 EH; S 517 MGH/SW; S 762 W
Viburnum rufidulum Raf., rusty blackhaw S 140 EH; S 294 HS; S 436 LSW; S 740 XR

Caryophyllaceae
Arenaria serpyllifolia L., thyme-leaf sandwort S 202 DG
Cerastium glomeratum Thuill. S 829 DG
Minuartia michauxii (Fenzl) Farw. var. *texana* (B.L. Rob.) Mattf., rock sandwort S 195 R/DG; S 626 DG; KRN 664 DG; ROK 12160 DG; JQ 146 DG
Paronychia virginica Spreng., Parks' nailwort S 433 DG; S 484 B
Siliene antirrhina L., sleepy catchfly S 203 DG
Stellaria media (L.) Vill., common chickweed WVM 20

Convolvulaceae
Convolvulus equitans Benth., Texas bindweed S 204 R/DG
Evolvulus nuttallianus Schult., hairy evolvulus S 168 EH; S 322 SW; S 1105 B
Ipomoea cordatotriloba Dennst. var. *cordatotriloba*, sharp-pod morning-glory S 443 R; S 761 R

Cornaceae
Cornus drummondii C.A. Mey., rough-leaf dogwood S 521 EH; S 913 HS/SW

Crassulaceae
Sedum nuttallianum Raf., yellow stonecrop S 254 GS; S 146 GS

Cucurbitaceae
Cucurbita foetidissima Kunth, buffalo gourd S 1077 B
Ibervillea lindheimeri (A. Gray) Greene, balsam gourd S 226 B; S 389a B

Cuscutaceae
Cuscuta exaltata Engelm., tree dodder ROK 20687 LSW
Cuscuta gronovii Willd. ex Schult., S 464 DG
Cuscuta indecora Choisy var. *indecora*, S 309 DG; S 358 B; S 502 EH; S 1125 B
Cuscuta obtusiflora Kunth var. *glandulosa* Engelm., red-dodder S 384 B
Cuscuta pentagona Engelm. var. *glabrior* (Engelm.) Gandhi, R.D. Thomas, S.L. Hatch, S 300 DG; S 328 B; S 1055 DG

Ebenaceae
Diospyros virginiana L., common persimmon S 294 LSW; S 374 LSW; S 771 MGH/SW

Euphorbiaceae
Acalypha ostryifolia Riddell, hop-hornbeam copperleaf S 421 GS
Chamaesyce fendleri (Torr. & A. Gray) Small, S 376 B; KRN 772 DG: ROK 12194 DG
Chamaesyce missurica (Raf.) Shinners, prairie spurge S 446 DG; S 498 EH; S 718 DG
Chamaesyce nutans (Lag.) Small, eyebane S 785 R; ROK 22674 R
Cnidoscolus texanus (Müll. Arg.) Small, Texas bull-nettle S 1114 B; WVM 225
Croton monanthogynus Michx., doveweed S 337 B; S 382 DG; S 455 DG; S 770 W; WVM 263
Croton texensis (Kl.) Muell., Texas croton ROK 22673 R
Ditaxis humilis (Engelm. & A. Gray) Pax var. *humilis*, low wild mercury KRN 750 R; KRN 1044
Euphorbia bicolor Engelm. & A. Gray, snow-on-the-prairie S 435 B
Euphorbia davidii Subils, S 776 W
Euphorbia dentata Michx., toothed spurge S 389 B; S 655 B
Euphorbia longicruris Scheele, wedge leaf euphorbia S 327 B
Euphorbia marginata Pursh., snow-on-the-mountain S 440 R; WVM 257
Euphorbia spathulata Lam., warty euphorbia S 199 R/DG; S 232 B; S 859 B; S 869 HS; ROK 12145 G
Phyllanthus polygonoides Nutt. ex Spreng, knotweed leaf-flower S 234 B; S 501 EH; S 574 L; S 885 DG; WVM 35; WVM 186
Stillingia texana I.M. Johnst., Texas stillingia S 311 DG; S 363 B; S 1058 DG; S 1079 B
Tragia brevispica Engelm. & A. Gray, short-spike noseburn S 648 B; WVM 255
Tragia ramosa Torr., catnip noseburn S 356 B; S 618 B; S 635 LSW; S 1057 DG

Fabaceae
Acacia angustissima (Mill.) Kuntze var. *hirta* (Nutt.) B.L. Rob., fern acacia S 619 EH; S 699 DG; S 774 EH
Astragalus lotiflorus Hook, lotus milk-vetch S 139 EH; S 817 EH/SW
Cercis canadensis L. var. *canadensis*, eastern red bud S 556 LSW
Cercis canadensis L., red bud S 132 EH
Chamaecrista fasciculata (Michx.) Greene, partridge-pea S 367 EH/SW; S 371 B
Dalea aurea Nutt. ex Pursh, golden dalea S 307 DG; S 372 B; S 698 DG; KRN 882
Dalea enneandra Nutt., big-top dalea S 369 B; KRN 880
Dalea frutescens A. Gray, black dalea S 747 DG
Dalea hallii A. Gray, Hall's dalea S 460 MGH; S 724 B; KRN 879
Dalea multiflora (Nutt.) Shinners, white-praire clover S 362 B
Dalea purpurea Vent., violet prairie-clover ROK 19614
Dalea reverchonii (S. Watson) Shinners, Comanche Peak prairie

clover S 255 DG; S 1049 DG; S 1136 DG; KRN 790 DG; KRN 875; ROK 12149 DG; SRK 314 R/DG; SRK 321 R/DG

Dalea tenuis (J.M. Coult.) Shinners, S 312 DG; S 429 E; S 366 EH/SW; KRN 878

Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald, Illinois bundle-flower S 284 HS; S 364 B

Gleditsia triacanthos L., common honey-locust S 754 DG

Indigofera miniata Ortega var. *miniata*, coast indigo S 320 SW; S 733 EH/SW

Lupinus texensis Hook, Texas bluebonnet S 179 B; S 927 B; WVM 41; WVM 167

Medicago arabica (L.) Huds., spotted bur-clover S 233A R

Medicago minima (L.) L., bur-clover S 563 R; S 571 L; S 233B R

Medicago sativa L., alfalfa S 623 R

Mimosa roemeriana Scheele, Roemer's sensitive briar S 258 EH; S 1060 DG; S 1249 B; S 1250 B

Pediomelum cuspidatum (Pursh) Rydb., tall-bread scurf-pea S 176 B; S 586 EH; S 906 B; KRN 885

Pediomelum cyphocalyx (A. Gray) Rydb., turnip-root scurf-pea S 347C B; ROK 12202 G; ROK 12159 G; KRN 886; KRN 762 EH; KRN 783 EH

Pediomelum hypogaeum Nutt. ex Torr. & A. Gray var. *scaposum*, edible scurf-pea S 326 B; S 853 B; ROK 12158 G

Pediomelum latestipulatum (Shinners) Mahler var. *latestipulatum*, Texas plains indian-breadroot S 213 B

Pediomelum latestipulatum (Shinners) Mahler, Texas plains indian-breadroot KRN 659 DG; ROK 20000 GS

Pediomelum linearifolium (Torr. & A. Gray) J.W. Grimes, S 351 EH; S 361 B

Pediomelum reverchonii (S. Watson) Rydb., rock scurf-pea S 354 B; S 705 B

Prosopis glandulosa Torr., honey mesquite S 570 B

Senna lindheimeriana (Scheele) H.S. Irwin & Barneby, Lindheimer's senna S 1235 B

Senna roemeriana Scheele, two-leaf senna S 302 R/DG, S 400 DG; S 749 DG; S 1052 DG; S 1121 B; TFR 229 DG

Tephrosia virginiana (L.) Pers., goat's rue S 417 LSW/SW

Vicia ludoviciana Nutt. ssp. *ludoviciana*, deer pea vetch S 856 B

Vicia villosa Roth ssp. *villosa*, hairy vetch S 554 EH/R

Fagaceae

Quercus buckleyi Nixon & Dorr, Texas red oak S 129 LSW; S 130 LSW

Quercus fusiformis Small, plateau live oak S 533 B; S 555 LSW; S 557 LSW; WVM 16

Quercus sinuata Walter var. *brevifolia* (Torr.) C.H. Mull, bastard oak S 575 L; S 751 LSW

Quercus stellata Wangenh., post oak S 492 B

Gentianaceae

Centaurium texense (Griseb.) Fernald, Texas centaury S 627 B; S 1139 GS; KRN 923; TFR 228 B

Eustoma russellianum (Hook.) G. Don, Texas bluebells S 686 B

Sabatia campestris Nutt., prairie rose gentian S 283 B; S 1131 B

Geraniaceae

Erodium cicutarium (L.) L'Hér ex Aiton, filaree S 120 GS; WVM 2

Erodium texanum A. Gray, storks-bill S 567 EH/R; S 900 DG; S 918 B

Geranium carolinianum L., crane's bill S 239 B; S 581 R

Geranium dissectum L. S 877 GS

Geranium texanum (Trel.) A. Heller, Texas geranium WVM 6

Juglandaceae

Carya illinoinensis (Wangenh.) K. Koch, pecan S 768 W; S 777 W

Krameriaceae

Krameria lanceolata Torr., trailing ratany S 589 B; S 1066 DG; S 1084 B; S 1108 B; TFR 224 B; WVM 205

Lamiaceae

Hedeoma acinoides Scheele, slender hedoma S 170 B; S 1097 B

Hedeoma drummondii Benth., Drummond's hedeoma S 1058 DG

Hedeoma hispida Pursh, rough hedeoma S 229 B

Hedeoma reverchonii A. Gray, Reverchon's false pennyroyal ROK 12152 G; ROK 20517 G

Lamium amplexicaule L., henbit S 577 L; WVM 9

Monarda citriodora Cerv. ex Lag., lemon beebalm S 280 B; S 1072 B

Rosmarinus officinalis L. S 822 L

Salvia azurea Michx. ex Lam var. *grandiflora* Benth., blue sage S 765 W; S 456 B; WVM 248

Salvia farinacea Benth, mealy-cup sage S 466 B

Salvia texana (Scheele) Torr., Texas sage S 158 B; S 845 B; S 883 DG

Scutellaria drummondii Benth., Drummond's skullcap S 200 R/DG; S 887 DG; WVM 159

Scutellaria drummondii Benth. var. *edwardsiana* B.L. Turner, Drummond's skullcap S 861 B; S 929 B

Scutellaria resinosa Torr., resin-dot skullcap S 167 EH; S 590 B

Scutellaria wrightii A. Gray, Wright's skullcap S 873 B; WVM 137; WVM 154; ELB 13641

Warnockia scutellarioides (Engelm. & A. Gray) M.W.Turner, prairie brazoria KRN 749 GS

Linaceae

Linum pratense (J.B. Norton) Small, meadow flax S 153 B; S 902 DG; KRN 754 GS

Linum rigidum Pursh, flax S 164 EH

Linum rupestre (A. Gray) A. Gray, rock flax ROK 12204 G

Linum sulcatum Riddell, grooved flax S 396 B; KRN 881

Loasaceae

Mentzelia oligosperma Nutt. ex Sims, stickleaf S 385 B; TFR 227 DG

Loganaceae

Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray, lax hornpod S 721 HS; S 515 MGS/SW

Lythraceae

Lythrum californicum Torr. & A. Gray, California loosestrife S 275 B; S 423 B; S 1247 HS/HWS

Malvaceae

Abutilon fruticosum Guill. & Perr., indian-mallow S 346 B; S 728 LSW; TFR 226 LSW

Callirhoe pedata (Nutt. ex Hook.) A. Gray, finger poppy-mallow S 166 EH; S 876 B; S 892 DG; WVM 160

Malva neglecta Wallr., common mallow S 576 SLW; WVM 141

Sida abutifolia Mill., spreading sida S 308 DG; S 694 DG

Sida spinosa L., prickly sida WVM 266

Menispermaceae

Cocculus carolinus (L.) DC., Carolina snailseed S 745 LSW; WVM 253

Moraceae

Maclura pomifera (Raf.) C.K. Schneid, bois d'arc S 711 W; S 769 W

Morus microphylla Buckley, Mexican mulberry S 752 DG; KRN 661

Nyctaginaceae

Mirabilis albida (Walter) Heimerl, white four-o'clock S 760 R; S 767 W

Mirabilis linearis Pursh., linear-leaf four-o'clock S 329 B

Oleaceae

Forestiera pubescens Nutt, elbow-bush S 121 G

Forestiera pubescens Nutt. var. *pubescens*, elbow-bush S 247 B

Fraxinus texensis (A. Gray) Sarg., Texas white ash S 127 LSW; S 1084b LSW RRR

Jasminum floridum Bunge, S 689 B

Ligustrum quihoui Carriere, Quihoui's privet S 494 B; S 727 LSW

Onagraceae

Calylophus berlandieri Spach ssp. *pinifolius* (Engelm. ex A. Gray) Towner, Berlandier's evening-primrose S 191 R/DG; S 1056 DG; WVM 128

Calylophus serrulatus (Nutt.) P.H. Raven, yellow evening-primrose S 695 DG

Gaura drummondii (Spach) Torr. & A. Gray, sweet gaura WVM 132

Gaura lindheimeri Engelm. ex A. Gray, white gaura WVM 129

Gaura suffulta Engelm. ex A. Gray, roadside gaura S 148 B; S 616 B/R; S 920 B; S 1234 B

Oenothera coryi W.L.Wagner, WVM 31

Oenothera macrocarpa Nutt. ssp. *macrocarpa*, fluttermill primrose S 185 EH; S 585 DG/R

Oenothera speciosa Torr. & A. Gray, Spach's evening-primrose S 289 GS; S 562 R; WVM 66; WVM 130; WVM 133

Oenothera triloba Nutt., stemless evening-primrose S 578 L; S 653 B; S 888 DG

Stenosiphon linifolius (Nutt. ex E. James) Heynh., false gaura S 353 EH/SW; S 369 B; S 450 DG; ROK 12150 G

Oxalidaceae

Oxalis stricta L., gray-green woodsorrel S 621 EH; S 632 LSW; WVM 63

Passifloraceae

Passiflora lutea L., yellow passion-flower S 1253 XR

Plantaginaceae

Plantago aristata Michx., bracted plantain S 298 GS; ROK 12146 DG

Plantago helleri Small, cedar plantain S 147 GS; S 919 B; S 1091 B; KRN 660 DG; KRN 662 DG; WVM 120

Plantago patagonica Jacq., bristle-bract plantain S 583 DG/R; S 1054 DG; S 1127 B

Plantago rhodosperma Decne., red-seed plantain S 246 B; S 659 B; S 854 B; S 889 DG; S 1039 GS; WVM 146

Plantago virginica L. pale-seed plantain S 860 B

Plantago wrightiana Decne., Wright's plantain S 241 B; S 297 GS; S 634 LSW; S 1093 B; TFR 223 B

Polemoniaceae

Ipomopsis rubra (L.) Wherry, standing-cypress S 357 B

Polygalaceae

Polygala alba Nutt., white milkwort S 187 EH; S 481 B; KRN 779

Polygonaceae

Eriogonum longifolium Nutt., long-leaf wild buckwheat S 453 DG; S 512 MGH/SW; S 722b B

Rumex crispus L., curly dock S 252 GS; WVM 127

Portulacaceae

Claytonia virginica L., Virginia spring beauty S 125 B

Portulaca pilosa L., chisme S 536 DG

Talinum calcarium S. Ware., limestone fame flower S 387 DG; S 625 DG; S 746 DG; S 1050 DG !

Primulaceae

Dodecatheon meadia L., common shooting-star S 593 LSW

Ranunculaceae

Anemone berlandieri Pritz, ten-petal anemone S 123 B; S 820 B; WVM 26

Delphinium carolinianum Walt. ssp. *virescens* (Nutt.) R.E.Brooks, prairie larkspur S 1134 LSW; S 1243 XR; KRN 788 R/B

Rhamnaceae

Ceanothus herbaceus Raf., S 1068 EH/SW; ROK 23003 R

Frangula caroliniana (Walter) A. Gray, Carolina buckthorn S 410 B/SW; S 739 XR

Rosaceae

Crataegus viridis L., greenhaw S 565 DG

Photinia serratifolia (Desf.) Kalkman, photinia S 741 XR

Prunus mexicana S. Watson, Mexican plum S 131 ES

Prunus rivularis Scheele, thicket plum S 316 B; WVM 316

Rosa setigera Michx. var. *tomentosa* Torr. & A. Gray, prairie rose S 321 SW; S 1248 HS/HWS

Sanguisorba annua (Nutt. ex Hook.) Torr. & A. Gray, prairie rose S 150 B; S 904 DG; ROK 12147 DG; ROK 12156 DG

Rubiaceae

Cephalanthus occidentalis L. buttonbush S 1245 GS/HWS

Galium aparine L., catchweed bedstraw WVM 10; WVM 50

Galium pilosum Aiton, hairy bedstraw S 687 LSW

Galium virgatum Nutt., southwest bedstraw S 136 EH; S 230 B; S 256b DG; S 847 B

Hedyotis nigricans (Lam.) Fosberg, prairie bluets S 475 B; S 1053 DG; S 1080 B; S 1110 B; TFR 230 B; WVM 273

Houstonia pusilla Schoepf, tiny bluet S 124 B

Sherardia arvensis L., field madder S 564 R; S 826 L; WVM 37; WVM 51

Rutaceae

Zanthoxylum hirsutum Buckley, prickley-ash S 217 B; S 401 EH; S 1135 LSW

Salicaceae

Populus deltoides Bartram ex Marshall, cottonwood S 801 R

Santalaceae

Comandra umbellata (L.) Nutt. ssp. *pallida* (A. DC.) Piehl, bastard toadflax KRN 761A

Sapindaceae

Cardiospermum halicacabum L., common balloonvine S 422 GS; S 757 P

Sapindus saponaria L. var. *drummondii* Hook & Arn, western soapberry S 296 LSW

Ungnadia speciosa Endl., Mexican buckeye S 134 LSW; S 388 DG; S 750 DG; WVM 43

Sapotaceae

Sideroxylon lanuginosum Michx. ssp. *oblongifolium* (Nutt.) T.D. Penn., chittamwood S 508 DG; WVM 43

Scrophulariaceae

Agalinis densiflora (Benth.) S. F. Blake, fine-leaf gerardia S 432 EH

Agalinis heterophylla (Nutt.) Small ex Britton, prairie agalinis S 465 B; S 469 B

Buchnera americana L., American bluehearts S 318 SW, ROK 20718 HS

Castilleja indivisa Engelm., Texas paintbrush S 156 B; WVM 234

Castilleja purpurea (Nutt.) G. Don var. *purpurea*, purple paintbrush S 155 B

Gratiola quartermaniae D. Estes, limestone hedge hyssop S 267 AQ/GS; S 566 AQ/GS; S 880 AQ/GS; ROK 20515B GS

Nuttallanthus texanus (Scheele) D.A. Sutton, Texas toad-flax S 864 B

Penstemon cobaea Nutt., wild foxglove S 184 EH; S 259 EH

Veronica peregrina L. ssp. *peregrina*, necklaceweed S 560 GS; S 561 GS

Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennell, Xalapa speedwell S 211 B

Solanaceae

Physalis heterophylla Nees, clammy ground cherry S 782 W/R

Solanum dimidiatum Raf., western horse-nettle S 286 R; WVM269

Solanum elaeagnifolium Cav., silver-leaf nightshade S 303 R/DG; ROK 22681 R

Solanum ptychanthum Dunal, American nightshade S 781 W/R

Solanum rostratum Dunal, buffalo-bur S 442 R; S 722 W

Ulmaceae

Celtis laevigata Willd. var. *reticulata* Torr., net-leaf hackberry S 228 B; S 507 DG

Ulmus americana L., American elm S 796 P; WVM 23

Ulmus crassifolia Nutt., cedar elm S 800 LSW

Urticaceae

Parietaria pensylvanica Muhl. ex Willd var. *pensylvanica*, hammer-wort S 649 LSW

Valerianaceae

Valerianella amarella (Lindh. ex Engelm.) Krok, hairy cornsalad S 143 GS; S 568 EH/R; S 849 B; S 874 B

Valerianella radiata (L.) Dufr. f. *parviflora* (Dyal) Egg. Ware, beaked cornsalad S 149 B; S 865 HS

Valerianella woodsiana (Torr. & A. Gray) Walp., Wood's cornsalad S 553 B

Verbenaceae

Glandularia bipinnatifida (Nutt.) Nutt., prairie verbena S 135 EH; S 620 EH; S 924 B

Glandularia pumila (Rydb.) Umber, pink verbena S 122 G; S 828 G

Lantana camara L., west Indian lantana S 691 B

Lippia nodiflora (L.) Michx., frogfruit S 374 B

Verbena halei Small, slender vervain S 703 GS; S 233b B; WVM 115

Vitex agnus-castus L. var. *agnus-castus*, common chastetree S 690 B

Violaceae

Hybanthus verticillatus (Ortega) Baill, nodding-green violet S 205 DG; KRN 789 DG

Viscaceae

Phoradendron tomentosum (DC.) Engelm. ex A. Gray, mistletoe S 534 B; WVM 1

Vitaceae

Cissus incisa Des Moul, cowitch S 390 B

Parthenocissus quinquefolia (L.) Planch, Virginia-creeper S 925 LSW

Vitis cinerea Engelm var. *cinera*, sweet grape S 295 LSW

Vitis mustangensis Buckley, mustang grape S 301 LSW/R; S 857 B, WVM 233

Vitis riparia Michx., river grape S 1252 XR

Vitis vulpina L., fox grape S 1256 XR

MAGNOLIOPHYTA: LILIOPSIDA

Agavaceae

Yucca arkansana McKelvey, Arkansas yucca S 260 EH

Yucca pallida McKelvey, pale yucca S 345 B; KRN 884

Commelinaceae

Commelina erecta L. var. *erecta*, dayflower S 437 LSW

Commelina erecta L. var. *angustifolia* (Michx.) Fernald, narrow-leaf dayflower S 347b R

Tradescantia humilis Rose, Texas spiderwort S 647 B

Tradescantia occidentalis (Britton) Smyth, prairie spiderwort S 190 WS

Tradescantia tharpii E.S. Anderson & Woodson, Tharp's spiderwort S 872 B

Cyperaceae

Carex cherokeensis Schwein., Cherokee caric sedge S 688 XR; S 1112 LSW; KRN 713 LSW

Carex microdonta Torr. & Hook., small-tooth caric sedge S 133 HS; S 142 GS; S 180 HS; S 335 HS; S 867 HS; S 1083 B; KRN 780 P

Carex muehlenbergii Schkuhr ex Willd. var. *enervis* Boott, S 178 B

Carex perdentata S.D. Jones, conspicuously-toothed caric sedge S 1236 B

Carex planostachys Kunze, cedar caric sedge S 169 EH; S 323 SW; S 631 LSW; S 652 B; S 818 EH/SW; S 1064 DG; S 1082 B; S 1109 B; S 1245 XR; KRN 777

Carex retroflexa Muhl. ex Willd., reflexed-fruit caric sedge S 1237 B

Cyperus acuminatus Torr. & Hook. ex Torr., taper-leaf flat sedge S 528 DG

Cyperus lupulinus (Spreng.) Marcks, slender flat sedge S 664 B

Cyperus setigerus Torr. & Hook., S 291 GS; WVM 268

Eleocharis montevidensis Kunth, S 337 HS; S 641 GS; S 611a GS; S 866 HS; S 878 GS; S 1035 GS

Eleocharis occulta S. G. Smith, limestone spikerush S 141 GS; S 173 HS; S 268 GS; S 341 HS; S 642 GS; S 870 HS; S 921 GS; S 1067 DG; KRN 658 HS; KRN 781 P RRR

Eleocharis palustris (L.) Roem. & Schult., large-spike spike-rush S 645 GS

Fimbristylis puberula Michx. var. *puberula*, S 317 HS/SW; S 333 HS; S 406 HS/SW; S 407 HS/SW; S 1081 B; KRN 778; KRN 782 P

Fuirena simplex Vahl var. *aristulata* (Torr.) Kral, S 265 GS; S 340 HS; S 409 HS/SW; S 701 GS; S 1242 HS/HWS

Rhynchospora nivea Boeck., snowy white-top sedge S 336 HS/SW

Scleria ciliata Michx., fringed nut-rush S 416 LSW/SW

Scleria verticillata Muhl. ex Willd, low-nut rush S 523 HS/SW

Iridaceae

Iris germanica L., garden iris S 824 L

Nemastylis geminiflora Nutt., prairie celestial S 137 EH; S 558 EH; S 569 B

Sisyrinchium langloisii Greene, pale blue-eyed grass S 165 EH; S 171 B; S 911 HS/SW; S 922 GS

Juncaceae

Juncus brachyphyllus Wiegand, small-head rush S 580 GS

Juncus bufonis L., toad rush S 215 GS; S 288 GS

Juncus capitatus Weigel, capped rush S 266 GS; S 613 GS

Juncus dudleyi Wiegand, Dudley's rush S 1042 HS

Juncus filipendulus Buckley, ring-seed rush S 1241 S/HWS; KRN 922; KRN 930; ROK 20002

Juncus interior Wiegand, inland rush S 580 GS; S 612 GS; S 643 GS; S 901 HS/SW; S 1133 B

Juncus marginatus Rostk., grass-leaf rush ROK 13319 GS

Juncus nodatus Coville, jointed rush ROK 20068 GS

Juncus texanus (Engelm.) Coville, Texas rush S 264b GS; S 343 HS; S 408 HS/SW; S 611 GS; S 700 GS; S 1043 HS; S 1246 HS/HWS

Juncus torreyi Coville, Torrey's rush S 299 GS; S 344 HS

Liliaceae

Allium canadense L. var. *hyacinthoides* (Bush) Ownbey & Aase, wild onion S 144 GS

Allium canadense L. var. *fraseri* Ownbey, wild onion S 183 EH; S 248 GS; S 1038 GS; KRN 753 GS

Allium drummondii Regel, prairie onion S 154 B; S 225 GS; S 850 B; S 864 HS; WVM 34

Camassia scilloides (Raf.) Cory, wild hyacinth S 222 B

Cooperia drummondii Herb., rain-lily S 380 DG

Cooperia pedunculata Herb., prairie rain-lily WVM 254

Erythronium mesochoreum Knerr, KRN 1387; KRN 1397

Muscari neglectum Guss. ex Ten., starch grape-hyacinth S 826 L

Nothoscordum bivalve (L.) Britton, crow poison S 488 B; S 537 GS; S 749 GS; S 868 HS

Zigadenus nuttallii (A. Gray) S. Watson, death-camass S 221 B; S 897 B

Orchidaceae

Spiranthes cernua (L.) L.C. Rich., nodding ladies'-tresses KRN 663 B

Spiranthes magnicamporum Sheviak, great plains ladies'-tresses S 486 B; S 529 HS; S 530 HS

Poaceae

Aegilops cylindrica Host, jointed goat grass S 1089 B; TFR 217 B

Agrostis perennans (Walter) Tuck., autumn bent grass S 214 GS
Andropogon gerardii Vitman ssp. *gerardii*, big bluestem S 457 MGH; ROK 22679 DG
Andropogon glomeratus (Walter) Britton, Sterns, & Poggenb., bushy bluestem S 525 HS/SW
Aristida lanosa Muhl. ex Elliott, woolly-sheath threeawn S 735 EH/SW
Aristida oligantha Michx., prairie threeawn S 795 EH/SW
Aristida purpurea Nutt. var. *longiseta* (Steud.) Vasey, red threeawn S 315 B; S 1087 B
Aristida purpurea Nutt. var. *nealleyi*, blue threeawn S 218 B; S 355 B; S 886 DG; S 903 DG; S 1070 EH/SW; S 1111 B; S 1116 B; S 1122 B
Aristida purpurea Nutt., var. *purpurea,* blue threeawn S 1119 B
Arundo donax L., giant reed S 798 B
Avena fatua L., wild oats S 193 R/DG
Bothriochloa barbinodis (Lag.) Herter var. *barbinodis*, cane bluestem S 428 EH; S 489 B; S 503 EH; S 1118 B
Bothriochloa ischaemum L. var. *songarica* (Rupr. Ex Fisch. & C.A.Mey) Celerier & Harlan, King Ranch bluestem S 342 HS; S 449 DG; S 452 DG; S 499 EH; S 907 B; S 1063 DG; WVM 282
Bothriochloa laguroides (DC.) Herter. ssp. *torreyana* (Steud.) Allred & Gould, silver bluestem S 352 EH/SW; S 370 B; S 719 DG
Bouteloua curtipendula (Michx.) Torr. var. *curtipendula*, side-oats grama S 451 DG
Bouteloua hirsuta Lag., hairy grama S 737 EH/SW; WVM 265
Bouteloua pectinata Feath., tall grama S 427 EH; S 458 MGH; S 473 B; S 725 B
Bouteloua rigidiseta (Steud.) Hitchc., Texas grama S 535 B; TFR 221 B
Briza minor L., little quaking grass S 292 GS
Bromus catharticus Vahl, rescue grass S 224 GS; WVM 65
Bromus japonicus Muhl. ex Willd, Japanese brome S 245 B; S 928 B; S 1036 GS; WVM 33
Bromus tectorum L. var. *tectorum*, cheat grass brome S 238 B
Buchloe dactyloides (Nutt.) Engelm., buffalo grass S 592 B; S 905 B; S 1130 B; WVM 149
Cenchrus spinifex Cav., common sandbur S 730 EH/SW
Chloris verticillata Nutt., tumble windmill grass S 582 R; WVM262
Coelorachis cylindrica (Michx.) Nash, Carolina joint-tail S 660 B
Desmazeria rigida (L.) Tutin, S 573 L
Digitaria cognata (Schult.) Pilg. ssp. *pubiflora* (Vasey) Wipff, western witch grass S 447 DG; S 506 EH; S 640 B
Eleusine indica (L.) Gaertn., goose grass WVM 264
Elymus canadensis L., Canada wild rye S 274 B; S 276 B; S 881 GS
Elymus virginicus L. Virginia wild rye S 1244 XR
Eragrostis curtipedicellata Buckley, gummy love grass S 493 B; S 637 B; S 789 B
Eragrostis intermedia Hitchc., plains love grass S 662 B
Eragrostis pilosa (L.) P.Beauv., India love grass S 663 B
Eragrostis secundiflora J. Presl. ssp. *oxylepis* (Torr.) S.D. Koch, red love grass S 734 EH/SW
Eragrostis sessilispica Buckley, tumble love grass KRN 889
Eriochloa sericea (Scheele) Munro ex Vasey, Texas cup grass S 654 B; S 1074 B
Erioneuron pilosum (Buckley) Nash, hairy tridens S 379 DG; S 588 DG; S 235 DG; S 1126 B
Hordeum pusillum Nutt., little barley S 151 B; S 208 DG; S 251 GS
Limnodea arkansana (Nutt.) L.H. Dewey, Ozark grass S 656 B; S 1065 DG; S 1101 B; S 1115 B; S 1132 B
Lolium perenne L. ssp. *perenne*, perennial rye grass S 196 R/DG; S 243 B; S 383 DG
Lolium perenne L., ssp. *multiflorum* (Lam.) Husn., Italian rye grass S 262 GS
Muhlenbergia reverchonii Vasey & Scribn., seep muhly S 438 GS; S 505 EH; S 726 B
Nassella leucotricha (Trin. & Rupr.) Barkworth, Texas winter grass S 278 B; S 1069 EH/SW; S 1120 B; TFR 220 B
Panicum aciculare Desv. var. *angustifolium* Elliott, needle-leaf rosette grass S 339 HS
Panicum acuminatum Sw. var. *lindheimeri* (Nash) Lelong, Lindheimer's rosette grass S 263 GS; S 338 HS; S 520 MGH/SW
Panicum acuminatum (Sw.) Gould & C.A.Clark, tapered rosette grass ROK 12205 GS
Panicum capillare L., witchgrass S 786 R; S 799 B
Panicum diffusum Sw., spreading panicum S 1129 B
Panicum hallii Vasey var. *hallii*, Hall's panic grass S 650 B
Panicum obtusum Kunth, vine mesquite S 277 B
Panicum oligosanthes Schult. var. *scribnerianum* (Nash) Gould, Scribner's rosette grass S 244 B; S 491 B
Panicum virgatum L., switchgrass S 468 HS/SW; 470 B; S 500 EH; S 524 HS/SW; S 615 R; S 692 DG
Phalaris caroliniana Walter, wild canary grass S 272 GS; S 644 GS
Poa annua L., annual bluegrass S 250 GS
Polypogon monspeliensis L., rabbit's-foot S 290 GS
Schedonnardus paniculatus Nutt., tumble grass S 324 B
Schizachyrium scoparium (Michx.) Nash, little bluestem S 461 MGH; S 477 B
Setaria parviflora (Poir) Kerguelen, knot-root bristle grass S 444 R
Setaria pumila (Poir.) Roem. & Schult., yellow bristle grass S 412 EH
Setaria reverchonii (Vasey) Pilg., Reverchon's bristle grass S 1117 B; ROK 12155 DG
Sorghastrum nutans (L.) Nash, yellow Indian grass S 462 MGH; S 485 B
Sorghum halepense (L.) Pers., Johnson grass TFR 222 B
Sporobolus compositus (Poir.) Merr. var. *drummondii* (Trin.) Kartesz & Gandhi, meadow dropseed S 471 B; S 504 EH; S 736 EH/SW; 791 B
Sporobolus ozarkanus Fernald, Ozark dropseed S 793 DG
Tridens albescens (Vasey) Wooton & Standl., white tridens S 249 GS; S 646 GS; S 914 GS; S 1128 B
Tridens flavus (L.) Hitchc., purpletop S 399 EH; S 738 XR
Tridens muticus (Torr.) Nash var. *elongatus* (Buckley) Shinners, rough tridens S 448 DG; S 479 B
Tridens muticus (Torr.) Nash var. *muticus*, slim tridens S 495 DG
Tripsacum dactyloides L., eastern gamma grass S 330 B
Trisetum interruptum Buckley, prairie trisetum S 209 GS; S 231 B; S 250b DG; S 1138 GS
Triticum aestivum L., bread wheat ROK 12140 R
Vulpia octoflora (Walter) Rydb. var. *octoflora,* common sixweeks grass S 894 DG; S 1062 DG

Smilacaceae
Smilax bona-nox L., saw greenbrier S 397 EH; S 518 MGH/SW; WVM 138
Smilax tamnoides L., devil greenbrier S 1256 XR/SW

Typhaceae
Typha domingensis Pers., narrow-leaf cat-tail S 285 HS

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