VEGETATIVE ANALYSIS OF MUHLY HILLSLOPE SEEPS IN NORTH CENTRAL TEXAS

by

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Submitted to the Graduate Faculty of the
College of Science and Engineering
Texas Christian University
in partial fulfillment of the requirements
for the degree of

Master of Science

May 2011

ACKNOWLEDGEMENTS

I would like to thank the following people for helping me accomplish this project. Without their help and support, I could not have completed this thesis.

First, I would like to thank Dr. Tony Burgess for everything. Without his time, knowledge, and support, I would not have finished this project. I learned to love the prairie because of him. I would also like to thank my committee members, Dr. Mike Slattery and Pete McKone, for their time and support during this project.

I would like to thank TCU, the Environmental Science Department, and my fellow graduate students for their support in this project. I would also like to thank the staff at the Botanical Research Institute of Texas (BRIT), the Fort Worth Nature Center and Refuge (FWNCR), and the United States Army Corps of Engineers (USACE) for allowing me to use their facilities.

I also would like to give many thanks to my thesis partner, Leslie Llado. She endured the trials and tribulations of this project with me and I am forever grateful to have had a thesis partner. It is because of her that I have developed a love of Sonic tatertots and limeades after fieldwork.

I would like to thank my family for loving and supporting me during my time at TCU. Lastly, I would like to thank my fiancée Nic, who put up with me when I was stressed and always loved and supported me. I would not be here without him.

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I. MUHLY SEEP SYSTEM OVERVIEW

The U.S. Geological Survey (USGS) (2009) defines a seep as a hydrogeologic formation that collects water from upslope or underground. Although seeps can be found in a variety of environments, this study specifically examines hillslope seeps that possess Seep Muhly (*Muhlenbergia reverchonii*), a perennial grass endemic to limestone grasslands in Texas and southern Oklahoma (Figure 1) (Ladybird Johnson Wildflower Center 2011).

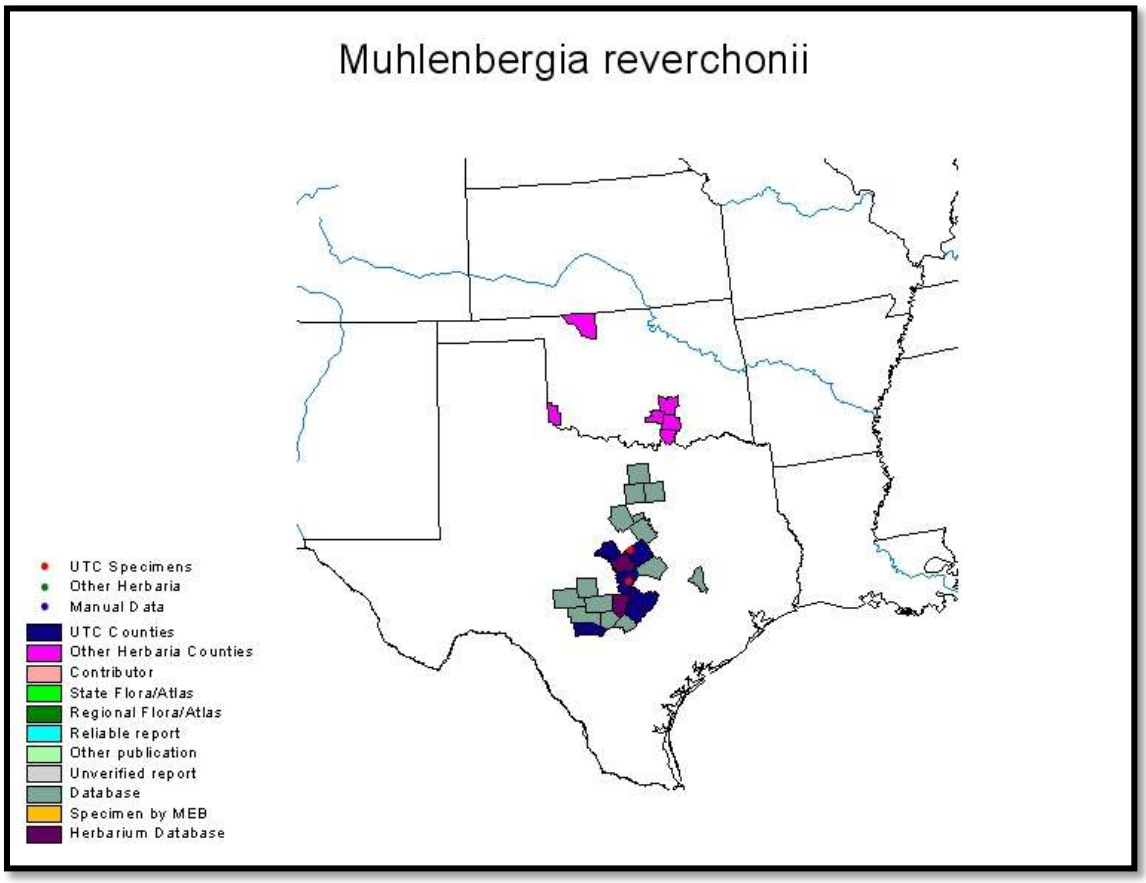

Figure 1: *Muhlenbergia reverchonii* distribution (Barkworth et al. 2007).

Muhly seeps are generally found on slopes where clayey marls or shales outcrop. The shale layers are interbedded between layers of limestone. Fractures in the limestone

allow water to infiltrate down to the shale layer, where it pools and resurfaces along exposed regions of shale (Figure 2).

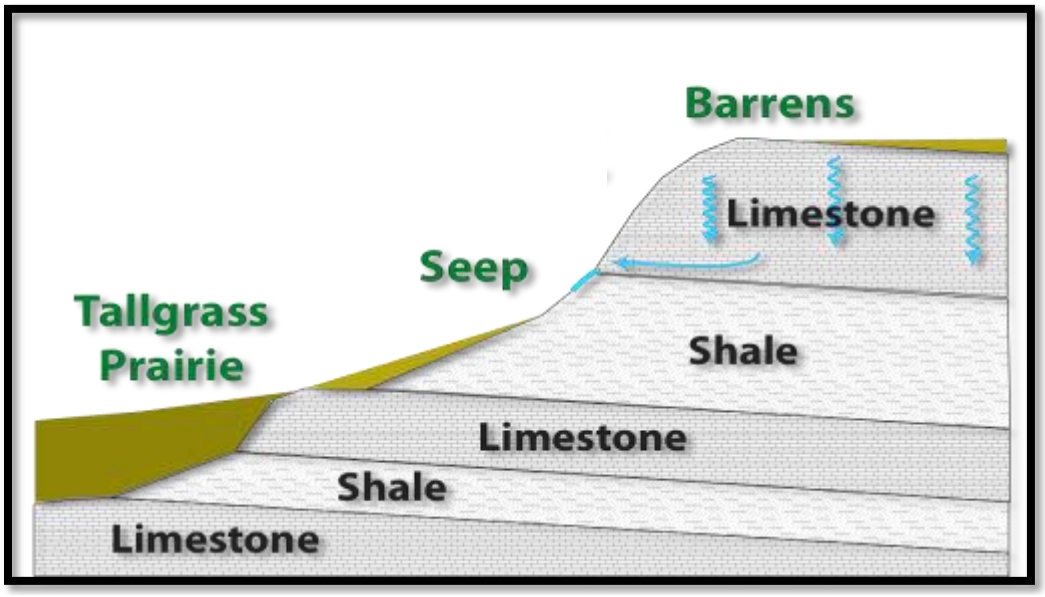

Figure 2: Cross-section of the underlying geology of a Muhly seep (Burgess 2010a).

Dyksterhuis (1946) refers to Muhly seeps as 'Muhly benches' and describes a process of severe saturation and desiccation. After heavy rainfall episodes, the Muhly seeps may become completely saturated because the soil water is unable to penetrate the shale layer and percolates laterally to the surface; however, by mid-summer they may become completely dry. This process closely resembles hyperseasonal hydrologic systems as described by Sarmiento and Solbrig (1984).

Sarmiento and Solbrig (1984) first identified the phenomenon of hyperseasonal hydrologic systems in the tropical savannas of Venezuela. Semiseasonal and seasonal savannas experience two moisture regimes throughout the year: saturation and partial drying in the case of semiseasonal savannas and saturation and complete drying in the case of seasonal savannas. Hyperseasonal savannas, however, experience four moisture regimes throughout the year: a period of complete anaerobic soil saturation, followed by

an aerobic drying period, then by a period of complete desiccation, and finally by an aerobic wet period. Aerobic processes are still present during the wet period, which differs from the exclusively anaerobic conditions found during complete soil saturation. Burgess (2010a) characterizes Muhly seeps as hyperseasonal hydrologic systems.

Private landowners possess over 94 percent of Texas' land (Schmidly et al. 2001). Consequently, research on Muhly seep systems has been restricted due to inaccessibility to study sites. Most research focuses on the vegetation of larger ecosystems that coincidentally include Muhly seeps rather than specifically examining seep systems themselves and is quite dated (e.g. Dale 1959; Dyskerhuis 1946; Fowler and Dunlap 1986).

A few vegetation associations involving *Muhlenbergia reverchonii* have been established on the Edwards Plateau at Fort Hood, Bell County, Texas (NatureServe 2011). The Edwards Plateau lies atop the Glen Rose Limestone formation, creating calcareous soils similar to those found in North Central Texas. *Muhlenbergia reverchonii* was observed on open, rocky slopes, in mesic areas near ephemeral to permanent streams as well as in depressions near grasslands or woodlands on level terrain (NatureServe 2011). These areas are similar to those examined in this study. The Ecological Society of American Vegetation Classification Panel (2010) also lists one vegetative community alliance between grasslands of limestone slopes and associated seeps on the Fort Worth Prairie and Edwards Plateau, although it has not yet been approved by the Panel. These associations, however, appear to be the extent of current research on the vegetation associated with Muhly seep systems.

II. OBJECTIVES

This study provides a description of the vegetation and soils associated with Muhly hillslope seeps in North Central Texas in order to further the understanding of these systems. To minimize confusion, the term 'hillslope seep' will be used to refer to Muhly seeps while 'Muhly seep system' will refer to the entire system (hillslope seep and associated barrens). The hydrologic aspect of the seep system is discussed elsewhere (Llado 2011). Vegetation was sampled from May to November of 2010. Transects were established at three study sites, and a quadrat-based sampling method was used at the primary study area east of Benbrook Lake.

No other known study has integrated the entire Muhly seep system in terms of vegetation, geology, pedology, and hydrology. The findings of this study may impact the delineation of seep systems as wetlands, which is the first step towards protection of these systems under Section 404 Permitting.

Muhly seep systems are fairly common in prairie systems in North Central Texas but possess perplexing hydrologic and vegetative characteristics due to their hyperseasonal nature. Thus, the question arose as to whether these systems are jurisdictional under the USACE.

According to Section 404 of the Clean Water Act, the USACE is responsible for the discharge of dredged or fill material into navigable waters. Navigable waters include: Territorial seas (seaward three nautical miles); traditional navigable waters (TNWs) and adjacent wetlands; non-navigable tributaries of TNWs and associated wetlands; associated wetlands abutting TNWs; and waters that have a significant nexus to TNWs. Significant nexus exists if the waters under analysis "significantly affect[s] the chemical,

physical and biological integrity of downstream traditional navigable waters" (Grumbles and Woodley 2007, 1).

Muhly seeps are currently not subject to Section 404 permitting because they do not possess significant nexus to a TNW and, at least superficially, fail to meet the vegetative, pedologic, and hydrologic requirements of a wetland as outlined in the USACE Wetlands Delineation Manual (1987) and Great Plains Regional Supplement (2008). However, an in-depth analysis of the vegetation, soils, and hydrology of Muhly seeps, particularly during saturated time periods, may demonstrate the presence of a previously unrecognized wetland system, which is the first step towards applicability of Section 404 permitting.

III. SITE DESCRIPTION

The Fort Worth Prairie

The Fort Worth Prairie, an area of open grassland that is the northern section of the Grand Prairie, lies between the Red River to the north and the Brazos River to the south and includes Fort Worth (Dyskerhuis 1946). The Texas EcoRegions Map, however, does not make this delineation and labels the region 'The Grand Prairie' (Figure 3). The Fort Worth Prairie is bounded by the Eastern and Western Cross Timbers, which consist of "light-colored sandy soils [in contrast] to the dark calcareous clays of the prairie" (Dyskerhuis 1946, 1).

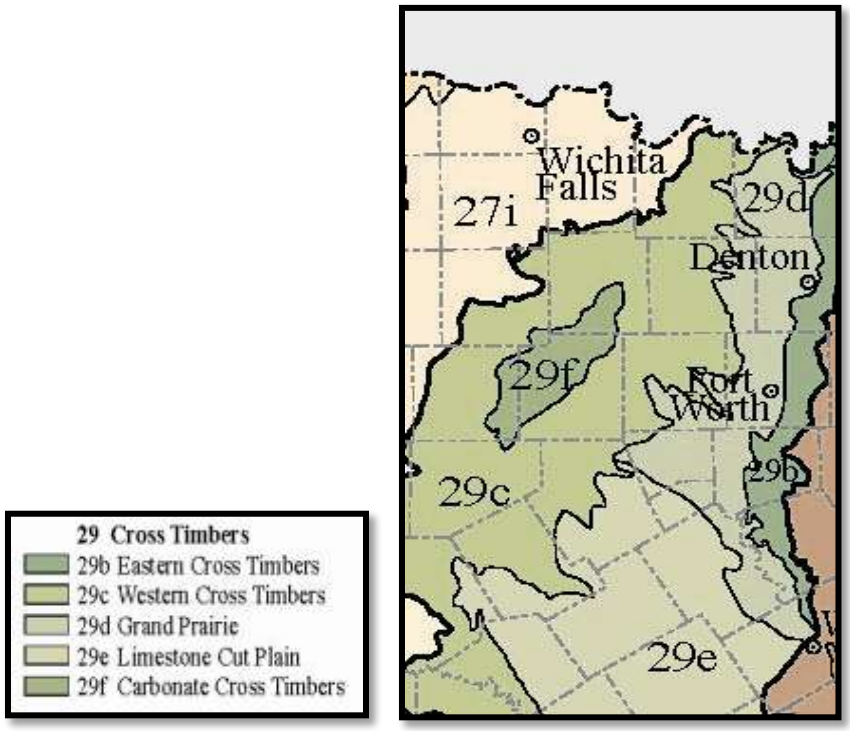

Figure 3: The Fort Worth Prairie. It is bordered by the Eastern and Western Cross Timbers. This map labels the Fort Worth Prairie as the Grand Prairie (Griffith et al. 2004).

At least three distinct vegetative zones exist on the Fort Worth Prairie:

1) Open 'barrens' areas characterized by "short grasses, forbs, prickly pear"

(especially *Opuntia phaeacantha*), "and yucca on shallow soils and limestone outcrops" (Burgess 2010a, 2). Recurring droughts heavily influence these xeric systems.

2) Muhly seeps that occur on hillslopes near depression areas. They are endemic to the region.

3) Tall and mixed grass prairies consisting of bands of little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii*). These grass species are found in deep, well-drained soils and occur in bunches or strands with little diversity (Dale 1959).

The barrens associated with Muhly seeps occur on thin calcareous clay soils relatively near the hillslope seeps and are distinguished from other barrens areas by the presence of *Muhlenbergia reverchonii* and close proximity to Muhly seeps (within approximately 10 m).

USACE Study Site

Our primary study site is located on USACE property east of Benbrook Lake southwest of Fort Worth, Tarrant County, Texas (32º 37' 27.8" N, 97º 25' 36.5" W). This land has remained relatively undisturbed for many years and is publically accessible. Although slightly altered by a pedestrian-equestrian road along a fenceline, this site offers a good example of a "pristine" Muhly seep on the Fort Worth Prairie.

The Fort Worth Prairie conforms with surface outcrops of several Cretaceous formations in the Washita and Fredericksburg Groups (Scott et al. 2003). At the USACE site, the Fort Worth Prairie lies atop the Duck Creek formation (McGowen et al. 1988).

Hill (1901) described this formation as “a series of chalky limestones and marls situated between the Kiamitia clays and the Fort Worth limestone of the Red River section” (257). It extends with decreasing thickness from Grayson and Cooke Counties to the Trinity River in Fort Worth. Bolar, Aledo, and Maloterre soil series have formed atop the Duck Creek formation at the USACE site (Ressel 1981).

Aledo series soils are “shallow, well drained, moderately permeable soils that formed in [Cretaceous] interbedded limestones and marls” (National Cooperative Soil Survey 1992). Bolar series soils are “deep, well drained ... soils that formed in interbedded limestones and calcareous marls” (National Cooperative Soil Survey 1989a). Maloterre soils are “very shallow, somewhat excessively drained, moderately slow permeable soils that formed in residuum weathered from limestone” (National Cooperative Soil Survey 1989b). The soils at the USACE site are a mixture of Bolar and Aledo series soils with pockets of Maloterre present. This site is characterized by low rolling hills of calcareous marl and limestone with alternating bands of Muhly hillslope seeps, tall and mixed grass prairies, and barrens areas that grade down towards Benbrook Lake.

Fort Worth Nature Center and Refuge

The Fort Worth Nature Center and Refuge (FWNCR) in northwest Fort Worth, Tarrant County, Texas (32° 50’ 7.18” N, 97° 28’ 6.13” W) served as a supplementary study site. The vegetation on two hillslope and one associated barrens area were examined three times over the course of eight months. The FWNCR lies at the western edge of the Fort Worth Prairie and shares many of the vegetative characteristics as the

USACE site (Griffith et al. 2004). However, this site sits atop the Walnut Limestone formation near its contact with Paluxy sandstone (McGowen et al. 1988). The Walnut formation is made of interbedded layers of calcareous clay and hard non-chalky limestone at the base of the Fredericksburg division, on the western fringe of the Fort Worth Prairie (Hill 1901). The FWNCR is composed of relatively high, flat ridgetops with savanna-grasslands and barrens, sloping down to the Trinity floodplain.

LBJ Grasslands

Unit 71 of the LBJ Grasslands in Wise County, Texas served as another supplementary study site. The vegetation on a hillslope seep was examined three times over the course of eight months. This site has a significantly different geologic composition from the USACE and FWNCR sites as it lies over the Antlers formation (McGowen et al. 1991). The soils are fine-grained, porous sand rather than the calcareous clays found at the other sites. There are occurrences of "layers of semicrystalline shell limestone sometimes occur in marly sand," which make Muhly seep formation possible (Hill 1901, 166; Scott et al. 2003). However, the seep is located just downslope (approximately 10 meters) of the contact point between the Anters and the Walnut Limestone formation, which is the same formation underlying the FWNCR. The compostion of this system is similar to the Muhly seeps at the FWNCR, which are located at the boundary between the Fort Worth Prairie and the Western Cross Timbers. The ridgetop is Fort Worth prairie barrens while the base of the slope is on the Western Cross Timbers (McGowen et al. 1988).

IV. METHODOLOGY

Vegetation

Several different zones within a toposequence were examined: hillslope seeps, contiguous barrens, and tallgrass zones topographically upslope and downslope from these areas. Transects were established at each study site (three at USACE, three at FWNCR, and two at LBJ Grasslands).

The three transect lines at the USACE site ran from an established fence line (east) to an ephemeral streambed (west) and included a hillslope seep, associated barrens, and tallgrass zones adjacent to these associations. The boundaries between the tallgrass areas and the seep and barrens were clearly marked with one-meter tall wooden stakes along each transect to avoid confusion in data collection. The associated barrens area was located downslope to the west of the hillslope seep. Plant species presence along the transects was recorded three times during an eight-month period (May through November 2010).

At the FWNCR, two hillslope seeps and one associated barrens, located upslope of the southernmost seep, were sampled. A single transect was established through each of the areas. Plant species presence along the transects was recorded three times during an eight-month period (May through November 2010).

Two hillslope seeps were sampled at the LBJ Grasslands. As with the other sites, plant species presence was recorded along the transects three times during an eight-month period (May through November 2010).

At the USACE study site different vegetation associations were more precisely described in order to define both structure and floristic composition for the hillslope seep, barrens, and tallgrass areas.

All vegetation at this site falls within the herb stratum, as defined by the USACE (1987), although there are noticeable differences in canopy height. The site was subdivided into patches that were based on vegetative or topographic distinctions. For instance, some patches were delimited by vegetative homogeneity, whereas others were differentiated because of changes in microtopography (berms, slope steepness, etc.). Twenty patches were defined for the spring and 28 patches for the fall.

Plant species within each patch were randomly sampled using $0.25m^2$ quadrats. Within each quadrat, cover class based on a range of percent canopy cover was recorded for each species according to the values in Table 1.

Table 1: Cover class values and corresponding percent canopy cover.

Cover Class	Range of Cover (%)
6	75-100
5	50-75
4	25-50
3	12.5-25
2	6.25-12.5
1	1-6.25
+	<1 Present
r	<<1 Very Rare

Quadrat sampling within the patch continued until a dominant species, determined by cover class rank, was consistently seen. For instance, if *Muhlenbergia reverchonii* was the dominant species for three continuous quadrats, and no significant number of new species appeared (approximately 95 percent of the total species), sampling for that patch

was complete. Each patch averaged approximately ten quadrats except for small patches completely sampled by a few quadrats. The process was repeated for fall vegetation.

Hydrophytic vegetation prevalence was evaluated for both the spring and fall sampling period. Dominants were determined using the 50/20 rule, which is the most common way to determine the prevalence of hydrophytic vegetation (USACE 2010). First, the community is divided into different plant growth form strata (tree, sapling, shrub, woody vine, and herb). In each stratum, the percent coverage of each species is estimated. Then the species are ranked in descending order and those species that have over 50 percent relative coverage are selected as the dominant species for that stratum. Any individual species that comprises over 20 percent of the relative coverage is also considered a dominant species. A wetland indicator code is assigned to each species (Table 2). If no indicator exists, a classification of 'NI' is given to the species. These species are omitted from the 50/20 rule because of the uncertainty in their status. Prevalence is then determined from the dominant species. Cover class is neglected at this stage. If over 50 percent of the dominants are FAC or wetter, the hydrophytic vegetation criteria have been met (USACE 2010).

If exactly 50 percent of the species are FAC or wetter species, the FAC-neutral test may be performed as a secondary test. The test is positive if all the species that have an indicator status of FACW- or wetter outnumber the number of species with a status of FACU+ or drier.

Table 2: Wetlands Indicator Status categories. Adapted from the USACE Great Plains Regional Supplement (2010).

Indicator Category	Indicator Symbol	Definition
Obligate Wetland Plants	OBL	Plants that occur almost always (estimated probability >99 percent) in wetlands under natural conditions, but which may also occur rarely (estimated probability <1 percent) in nonwetlands. Examples: *Carex microdonta, Juncus texanus*.
Facultative Wetland Plants	FACW	Plants that occur usually (estimated probability >67 percent to 99 percent) in wetlands, but also occur (estimated probability 1 percent to 33 percent) in nonwetlands. Examples: *Lippia nodiflora* and *Phalaris caroliniana.*
Facultative Plants	FAC	Plants with a similar likelihood (estimated probability 33 percent to 67 percent) of occurring in both wetlands and nonwetlands (estimated probability 1 percent to 33 percent) in nonwetlands. Examples: *Muhlenbergia reverchonii* and *Juncus tenuis*.
Facultative Upland Plants	FACU	Plants that occur sometimes (estimated probability 1 percent to 33 percent) in wetlands, but occur more often (estimated probability >67 percent to 99 percent) in nonwetlands. Examples: *Andropogon gerardii* and *Sorghastrum nutans*.
Obligate Upland Plants	UPL	Plants that occur rarely (estimated probability <1 percent) in wetlands, but also occur almost always (estimated probability >99 percent) in nonwetlands under natural conditions. Examples: *Artemisia ludoviciana*.

Species within each quadrat were ranked in order of cover class dominance. Within each patch, the sum of the cover class ranks for each species was determined. That value was then divided by total number of quadrats within the patch to generate an average cover class for the entire patch. If a species did not appear in a quadrat, it was assigned a value of 0. The average value was rounded to the nearest whole number. Values ending with 0.5 were rounded up. Both high and low percentage values were assigned to each cover class to determine the total percentage of the sample area. Since the cover class ranks correspond to a percentage bracket, it is possible to use the 50/20 dominance rule. It should be noted that the 50/20 rule does not include non-vegetated areas. For instance, if the sampled vegetation covered only 60 percent of the available area sampled, dominant species would need to cover at least 12 percent.

Pedology

A description of soil profiles was performed at the USACE site only due to time constraints. Six soil pits in different zones along Transect 2 were dug in February 2011 (Figure 4). Soil horizons were determined in the field. Samples from each horizon were sent to the Texas A&M University Soil, Water and Forage Testing Laboratory for analysis of pH, texture, and nutrient and organic matter content.

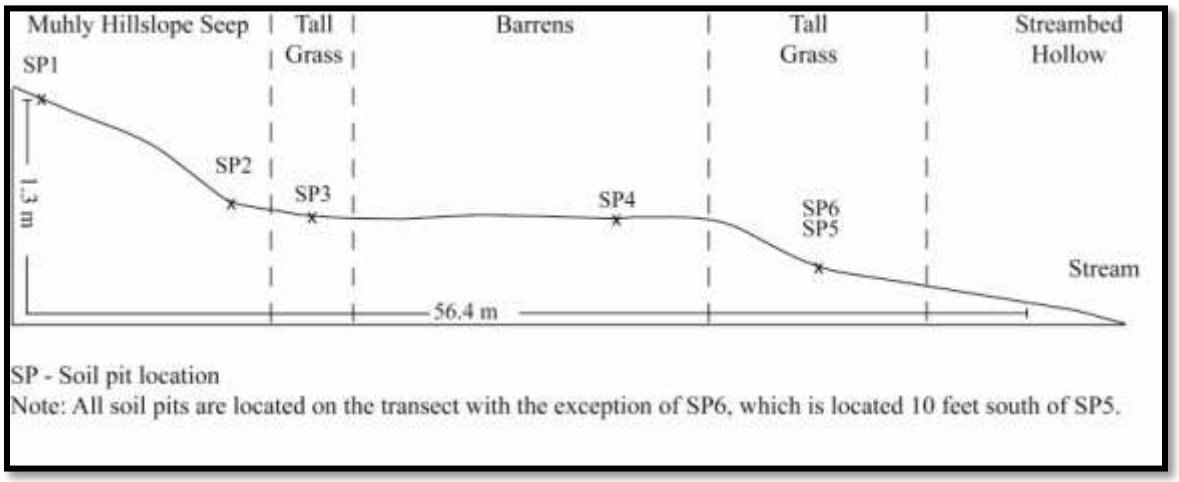

Figure 4: Soil pit locations along Transect 2. The dashed lines separate the different zones. Adapted from Llado (2011).

V. RESULTS

Vegetative Analysis at USACE

A total of 124 species from 34 families were documented from the three study sites. The three largest families were *Asteraceae* (26 species), *Poaceae* (17 species) and *Cyperaceae* (11 species). A complete list of species may be found in Appendix A.

At the USACE site, a total of 337 quadrats sampled vegetation, 133 quadrats in the spring and 204 in the fall. Figures 5 and 6 show the placement of vegetative associations, or patches, at the USACE study site for both spring and fall.

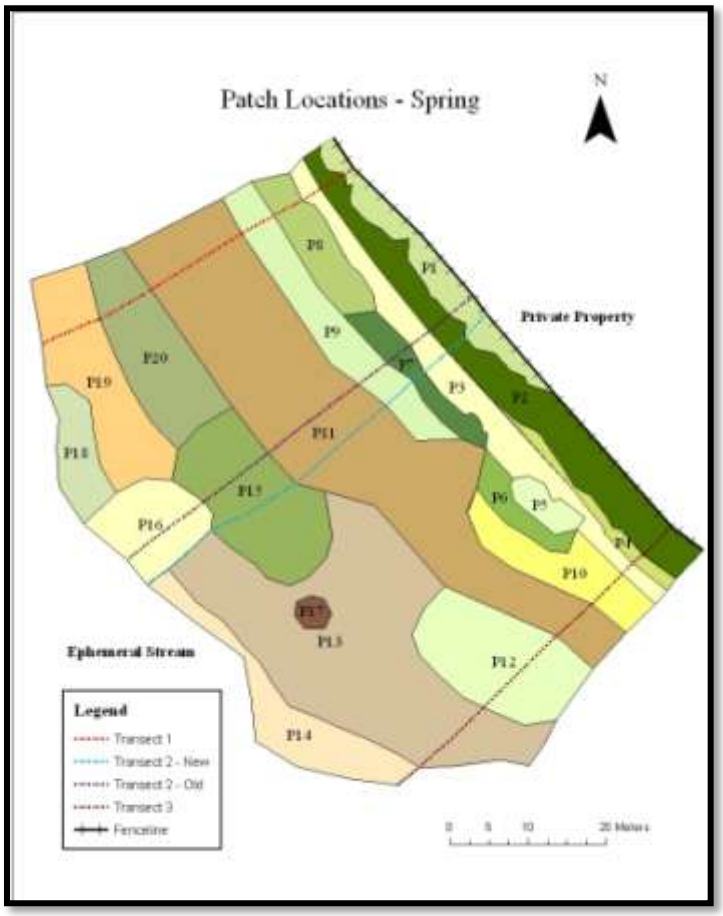

Figure 5: Patch locations during spring sampling season. Patches were mapped using data collected with a Leica 1200 Total Station unit.

Table 3: Descriptions of patches sampled during the spring.

Patch	Description	Patch	Description
1	Dominated by *Centaurea americana* and *Cirsium undulatum*, which are absent downslope. *Muhlenbergia reverchonii* present.	11	Barrens. Hetereogenous mixture of vegetation. *Muhlenbergia reverchonii* present.
2	Dominated by *Muhlenbergia reverchonii*. *Carex microdonta* and *Eleocharis montevidensis* present. *Centaurea americana* and *Cirsium undulatum* absent or minimally present.	12	Dominated by *Schizachyrium scoparium* and *Andropogon gerardii*. Barrens vegetation absent.
3	Dominated by *Carex microdonta* and *Eleocharis montevidensis*. *Muhlenbergia reverchonii* present but limited due to land disturbance.	13	Heterogenous mixture of vegetation; no visible dominant species. Extends to streambed.
4	On berm. Grasses and thistles on berm while flat area is dominanted by *Juncus texanus*. Heterogenous mixture of plants.	14	Dominated by *Dracopis amplexicaulis*. *Andropogon gerardii* and *Schizachyrium scoparium* absent. Extends to streambed. Debris present.
5	Dominated by *Juncus texanus*.	15	Dominated by *Andropogon gerardii*.
6	On berm. Heterogenous mixture of plants.	16	Heterogenous mixture of vegetation; similar to Patch 14. Trees present. Extends to streambed.
7	On berm. Heterogenous mixture of plants.	17	Transition area between *Schizachyrium scoparium* and *Andropogon gerardii*. Barrens vegetation absent.
8	Dominated by *Andropogon gerardii*.	18	Dominated by annual forbs, *Carex microdonta*, *Allium runyonii*, *Eleocharis montevidensis*. *Muhlenbergia reverchonii* present but not dominant.
9	Dominated by *Schizachyrium scoparium*.	19	Dominated by *Andropogon gerardii*.
10	Dominated by *Schizachyrium scoparium*. Separated from Patch 9 by the barrens.	20	Mixture of barrens vegetation and *Andropogon gerardii*. Steep slope.

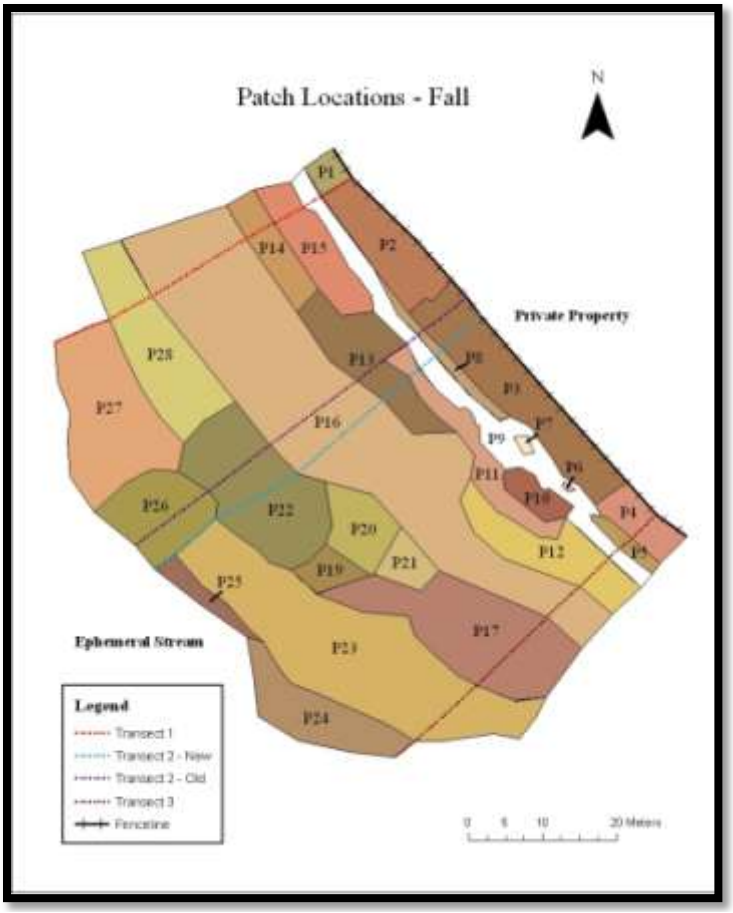

Figure 6: Patch locations during fall sampling season. Patches were mapped using data collected with a Leica 1200 Total Station unit.

Table 4: Description of patches sampled during the fall.

Patch	Description	Patch	Description
1	Dominated by *Sorghastrum nutans* and *Muhlenbergia reverchonii*.	15	Dominated by *Muhlenbergia reverchonii*. Similar vegetation Patch 9 but with short grasses present.
2	Domianted by *Muhlenbergia reverchonii*. Other grass species present.	16	Barrens.
3	Dominated by *Muhlenbergia reverchonii.* Very few other grass species.	17	Dominated by *Schizachyrium scoparium*. *Muhlenbergia reverchonii* and *Tridens muticus* absent.
4	Dominated by *Ambrosia trifida* and *Muhlenbergia reverchonii*.	18	Dominated by *Schizachyrium scoparium*. Sharp slope to streambed.
5	On berm. Dominated by *Ambrosia trifida*.	19	Dominated by *Eragrostis curtipedicellata*. Surrounded by *Andropogon gerardii*.

Continuation of Table 4: Description of patches sampled during the fall.

Patch	Description	Patch	Description
6	Isolated patch of vegetation.	20	Dominated by *Schizachyrium scoparium*. *Andropogon gerardii* and *Ambrosia trifida* present. *Muhlenbergia reverchonii* absent.
7	Isolated patch of vegetation.	21	Dominated by *Ambrosia trifida, Schizachyrium scoparium,* and *Andropogon gerardii*.
8	Hollow area of seep. Dominated by sedges like *Carex microdonta* and *Lippia nodiflora*.	22	Dominated by *Andropogon gerardii*. *Ambrosia trifida* present. *Schizachyrium scoparium* absent.
9	Pathway. Heterogenous mixture of vegetation. Patches of bare ground present.	23	Dominated by *Andropogon gerardii*. Extends to streambed.
10	Dominated by *Iva angustifolia* and *Ambrosia trifida*.	24	Dominated by *Teucrium canadense*. More debris, less grass species. *Andropogon gerardii* absent.
11	On berm. Dominated by *Iva angustifolia* and *Ambrosia trifida*.	25	Slopes into streambed. Dominated by *Carex microdonta*, *Eleocharis montevidensis,* and debris.
12	Dominated by *Schizachyrium scoparium*. Similar vegetation to Patch 13.	26	Dominated by *Ambrosia trifida*. *Andropogon gerardii* present.
13	Dominated by *Schizachyrium scoparium*. Similar vegetation to Patch 12.	27	Flat area between slope and streambed. Sedges present. Grasses absent.
14	Dominated by *Andropogon gerardii*. Topographically lower than toe of hillslope.	28	Sharp slope. Dominated by mixture of barrens vegetation and *Schizachyrium scoparium*. *Carex microdonta* and *Eleocharis montevidensis* absent.

Although the vegetative patches were analyzed separately, they can be grouped together into four general zones: the hillslope seep, associated barrens, tallgrass areas dominated either by *Schizachyrium scoparium* or *Andropogon gerardii*, and a streambed hollow zone. The zones were differentiated by their dominant species and soil composition. Tables 5 and 6 list the dominant species found in each patch per sampling season, determined by the 50/20 rule. The prevalence of hydrophytic vegetation, one criterion for wetlands delineation, was also determined.

Table 5: Dominant species per patch during spring sampling.

Spring Hydrophytic Vegetation Determination				
Patch	**Dominant Species**	**Wetland Indicator Status**	**Species FAC or Wetter (%)**	**Hydrophytic Vegetation Prevalent**
1	*Centaurea americana*	NI	0	
2	*Muhlenbergia reverchonii*	FAC	100	x
3	*Carex microdonta*	OBL	100	x
	Eleocharis montevidensis	FACW+		
	Muhlenbergia reverchonii	FAC		
4	*Symphyotrichum ericoides*	FACU-	0	
5	*Juncus texanus*	OBL	100	x
6	*Bifora americana*	NI	0	
7	*Carex microdonta*	OBL	100	x
8	*Andropogon gerardii*	FACU	0	
9	*Schizachyrium scoparium*	FACU+	0	
	Hedyotis nigricans	NI		
10	*Schizachyrium scoparium*	FACU+	0	
11	No dominants		0	
12	*Schizachyrium scoparium*	FACU+	0	
	Symphyotrichum ericoides	FACU-		
13	No dominants		0	
14	*Ambrosia trifida*	FAC	100	x
	Dracopis amplexicaulis	FAC+		
15	*Andropogon gerardii*	FACU	0	
16	*Ambrosia trifida*	FAC	0[1]	
	Bromus arvensis	FACU		
17	*Symphyotrichum ericoides*	FACU-	0	
18	*Eleocharis montevidensis*	FACW+	0[2]	
	Symphyotrichum ericoides	FACU-		
19	*Andropogon gerardii*	FACU	0	
20	*Andropogon gerardii*	FACU	0	

[1]FAC-neutral test was performed.
[2]Other criterion must be used to delineate wetland.

Table 6: Dominant species per patch during fall sampling.

Fall Hydrophytic Vegetation Determination				
Patch	**Dominant Species**	**Wetland Indicator Status**	**Species FAC or Wetter (%)**	**Hydrophytic Vegetation Prevalent**
1	*Symphyotrichum ericoides*	NI	0	
2	*Muhlenbergia reverchonii*	FAC	100	x
3	*Muhlenbergia reverchonii*	FAC	0*	
	Symphyotrichum ericoides	FACU-		
4	*Ambrosia trifida*	FAC	75	x
	Carex microdonta	FAC		

Table 6: Dominant species per patch during fall sampling.

Fall Hydrophytic Vegetation Determination				
Patch	**Dominant Species**	**Wetland Indicator Status**	**Species FAC or Wetter (%)**	**Hydrophytic Vegetation Prevalent**
4	*Muhlenbergia reverchonii*	OBL		
	Symphyotrichum ericoides	FACU-		
5	*Symphyotrichum ericoides*	FACU-	0	
6	*Symphyotrichum ericoides*	FACU-	0	
7	*Carex microdonta*	OBL	100	x
	Dichanthelium acuminatum var. *lindheimeri*	FAC		
	Tridens muticus	FACW*		
8	*Symphyotrichum ericoides*	FACU-	0	
9	*Carex microdonta*	OBL	100	x
	Tridens muticus	FACW*		
10	*Ambrosia trifida*	FAC	100	x
	Iva angustifolia	NI		
11	*Ambrosia trifida*	FAC	100	x
12	*Schizachyrium scoparium*	FACU+	0	
13	*Muhlenbergia reverchonii*	FAC	0[2]	
	Symphyotrichum ericoides	FACU-		
14	*Ambrosia trifida*	FAC	0[2]	
	Andropogon gerardii	FACU		
15	*Ambrosia trifida*	FAC	100	x
	Muhlenbergia reverchonii	FAC		
	Tridens muticus	FACW*		
16	*Tridens muticus*	FACW*	100	x
17	*Symphyotrichum ericoides*	FACU-	0	
18	*Schizachyrium scoparium*	FACU+	0	
	Rosa foliolosa	NI		
19	*Eragrostis curtipedicellata*	NI	0	
20	*Andropogon gerardii*	FACU	0	
	Schizachyrium scoparium	FACU+		
21	*Ambrosia trifida*	FAC	100	x
22	*Andropogon gerardii*	FACU	0	
23	*Andropogon gerardii*	FACU	0	
24	*Teucrium canadense*	FACW-	100	x
25	*Eleocharis montevidensis*	FACW-	100	x
26	*Ambrosia trifida*	FACW-	100	x
27	*Ambrosia trifida*	FACW-	0[2]	
	Symphyotrichum ericoides	FACU-		
28	*Croton monanthogynus*	NI	0	

*Wetland indicator status under review.
[1]FAC-neutral test was performed.
[2]Other criterion must be used to delineate wetland.

The hillslope seep was differentiated from other areas by the dominance of *Muhlenbergia reverchonii*. Muhly hillslope seeps are characterized by soils that experience of periods of severe saturation and desiccation and do not drain well (Llado 2011). *Schizachyrium scoparium* and *Andropogon gerardii*, which border the seep in dense bands at the USACE site, thrive in deep, well-drained soils. Also, little intermixing between *M. reverchonii* and *S. scoparium* or *A. gerardii* occurred and these areas could be easily distinguished as separate zones.

During the spring, patches 1, 2, 3, 4, 5, 6, and 7 were located approximately on the hillslope seep. A noticeable difference in vegetation was seen between the hillslope and the depression at the toe of the slope. The hollow pools more water, especially during the wet season. This section may be an artifact of the pedestrian-equestrian walkway created along the fence line, however. Patches 1, 2, and 4 were located on the hillslope while patches 3, 5, 6, and 7 were in the hollow. For the fall, patches 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 were located approximately on the hillslope seep. Specifically, patches 1, 2, 3, and 4 were found on the hillslope and patches 5, 6, 7, 8, 9, and 10 were in the hollow.

Symphyotrichum ericoides was dominant in many of the patches. This herbaceous, rhizomatous perennial is found in disturbed or open areas and is widespread throughout the USACE site (Diggs et al. 1999). Given its FACU- wetland indicator status, it was surprising to discover it mixed with *Carex microdonta*, an obligate wetland plant. *Carex microdonta, Eleocharis montevidensis,* and *Muhlenbergia reverchonii* were dominant in the hollow of the seep. It appears that at least part of the hollow of the seep meets the hydrophytic vegetation requirements year round.

The barrens area associated with Muhly hillslope seeps was differentiated from other zones by its very shallow soils over limestone and the relative scarcity of large stands of taller grasses except along its eastern and western borders. It was the most diverse zone, with 28 species found in spring and 16 species found in fall.

Muhlenbergia reverchonii was not the most dominant species in the barrens during the spring. As the season progressed, however, it was observed that *M. reverchonii* became the dominant grass species on the barrens. However, at the time of fall sampling, *Tridens muticus* had become the dominant grass species, athough *M. reverchonii* was still present.

The tallgrass zones bordered the hillslope seep and the barrens area. They were generally dominated by *Schizachyrium scoparium* and *Andropogon gerardii*. *Schizachyrium scoparium* is considered either a mixed or tallgrass; for this study it is considered a tallgrass because of its association with *A. gerardii*. These species thrive in deeper, well-drained soils, which differ from both the hillslope seep and the barrens, and are noticeably taller than other areas. The tallgrass zone was divided into two areas: upslope and downslope of the barrens.

The upslope zone was located downslope of the hillslope seep and upslope of the barrens. During the spring, patches 12, 13, 15, 17, and 19 may grouped in the downlope tallgrass zone and during the fall, patches 12, 13, 14, and 15 may be included in this zone.

Schizachyrium scoparium dominated the upslope tallgrass zone during both the spring and fall. The downslope tallgrass zone was dominated by *S. scoparium* and *Andropogon gerardii* during the spring and *A. gerardii* in the fall. *Rosa foliolosa*, the

white prairie rose, appeared on both the barrens and within *A. gerardii* strands, suggesting that this species is not limited to the barrens.

The streambed hollow area lies to the west of the western transition zone. It is distinguished from the downslope tallgrass zone by its lack of thick strands of tallgrass species. It also possesses many species found on a hillslope seep, most notably *Muhlenbergia reverchonii, Carex microdonta,* and *Eleocharis montevidensis*. While the other hillslope seeps in the study are predominantely influenced by their underlying geology, the streambed hollow is greatly influenced by the ephemeral stream that borders its western edge. This phenomenon has been seen elsewhere, most notably west of Rhome, Wise County, Texas, and may represent another type of Muhly seep other than a hilllslope seep. However, this study focuses on Muhly hillslope seeps that have minimal hydrological interactions with ephemeral streams. Further research will be needed to desribe this system.

The presence of *Andropogon gerardii,* a tallgrass species, in the spring may be due to the close proximity of the streambed hollow to stands of *A. gerardii*. *Eleocharis montevidensis* was the dominant species during the fall in the streambed hollow. This differs from the hollow of the hillslope seep, where *E. montevidensis* was minimally present in the fall. These areas are comparible because of their locations in depressions at the bottom of slopes. These areas tend to have enough water to sustain many obligate or facultative wetland plants. Mixed grass species such as *Muhlenbergia reverchonii* and *Sporobolus compositus* var. *drummondii* were present but tallgrass species were absent.

Vegetative Comparison Among Sites

Transects at all three study sites were sampled three times during the study (May, July, and October 2010). A list of species found along each transect for the sampling periods may be found in Appendix C.

The only species consistently seen at all three hillslope seeps were *Muhlenbergia reverchonii*, *Carex microdonta*, and an *Eleocharis* species, either *E. montevidensis* or *E. occulta*. *Carex microdonta* and both *Eleocharis* species declined in occurrence as the year progressed because they are cool-season perennials, leaving *M. reverchonii* as the only species seen at all sites throughout the year.

Bifora americana, Ambrosia trifida, Bromus arvensis, and *Croton monanthogynus* were common species found at both the USACE study site and the Fort Worth Nature Center and Refuge (FWNCR). *Dichanthelium acuminatum* var. *lindheimeri, Iva angustifolia, Hedyotis nigricans, Marshallia caespitosa, Symphyotrichum ericoides,* and *Juncus texanus* were species found at both the USACE and the LBJ Grasslands. *Eleocharis* species were observed at both the FWNCR and LBJ Grasslands late in the fall whereas it was absent or minimally present at the USACE site during the same time period.

Barrens areas were also compared between the USACE study site and the FWNCR. *Muhlenbergia reverchonii, Castilleja indivisa, Monarda citriodora, Plantago patagonica, Hedyotis nigricans, Gaillardia pulchella, Ambrosia trifida,* and *Croton monanthogynus* were common species seen at both sites. *Muhlenbergia reverchonii* was more prevalent on the barrens at the FWNCR than at the USACE site.

Pedologic Analysis

Table 8 summarizes the results from the field and lab analysis. Detailed soil pit photos are located in Appendix D. Soils were sampled along Transect 2 at the USACE site (Figure 7). Master horizons were classified according to Table 7.

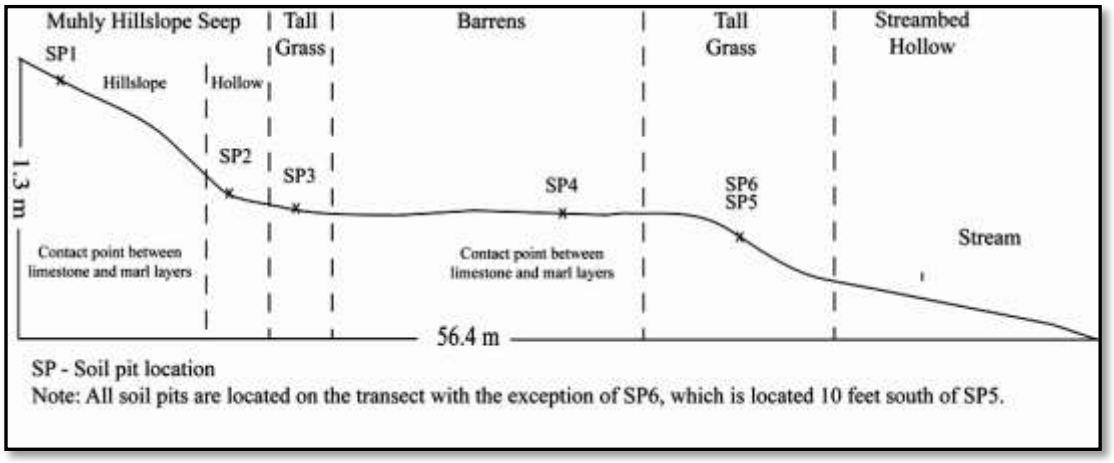

Figure 7: Description of soil pit locations at USACE site. Adapted from Llado's (2011) thesis

Table 7: Soil horizon description. Adapted from Soil Survey Staff (2010).

Horizon	Description
O	Dominated by organic soil materials.
A	Mineral horizon that exhibit obliteration of all or much of the original rock structure and show one or both of the following: (1) an accumulation of humified organic matter closely mixed with the mineral fraction and not dominated by E or B horizon or (2) properties resulting from cultivation, pasturing, or similar kinds of disturbance.
B	Dominated by obliteration of all or much of the orignal rock structure and show one or more of the following: (1) illuvial concentration of silicate clay, iron, aluminum, humus, etc.; (2) Evidence of removal, addition, or transformation of carbonates and/or gypsum; (3) residual concentration of oxides; (4) coatings of sesquioxides that make the horizon conspicuously lower in color, higer in chroma, or redder in hue; (5) Formation of silicate clay or liberates oxides and form granular, blocky, or prismatic structure; (6) brittleness; (7) strong gleying.
R	Strongly cemented to indurated bedrock.

Table 8: Soil data analysis summary from Texas A&M Soil, Water, and Forage Testing Laboratory. All samples were taken from the USACE study site.

Soil Pit	Horizon	Depth	pH	Calcium	Sand	Silt	Clay	Color Hue Value/Chroma	Lab Textural Class	Field Determined Textural Class	Rock Fragment Size and %	Organic Matter
				(ppm)	%	%	%					%
1-East	A1	0"-1"	n/a	n/a	n/a	n/a	n/a	10 YR 3/2	n/a	loamy clay	Few fragments	n/a
	A2	1"-7"	8	39675	36	30	34	10 YR 3/2	clay loam	silty clay loam to clay loam	Abundant fragments	4.63
	C	7"-9"	8.1	44815	40	22	38	2.5Y 5/2	clay loam	silt loam to silty clay loam	a	3.16
	R[1]	9"+	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		n/a
1-West	A1	0"-1"	n/a	n/a	n/a	n/a	n/a	10YR 3/2	n/a	loamy clay	Few fragments	n/a
	A2	1"-8"	8	44620	45	27	28	10YR 3/2	clay loam	silty clay loam to clay loam	Abundant fragments	1.76
	C1	8"-11"	8.1	45824	44	20	36	2.5Y 5/2	clay loam	silt loam to silty clay loam	a	0.97
	C2	11"-16"	7.9	45294	41	21	38	2.5Y 5/3	clay loam	silt clay loam	b	2.01
	C3	16"-18"	7.9	44916	36	24	40	2.5Y 6/3	clay	clay loam	c	1.84
	C4	18"-27"+	7.9	44703	28	30	42	2.5Y 8/3	clay	silt loam to loam	d	1.02
2	A1	0"-1"	n/a	n/a	n/a	n/a	n/a	10YR 4/2	n/a	loamy clay	Few fragments	n/a
	A2	1"-13"	7.8	41546	33	33	34	10YR 4/2	clay loam	clay	Few fragments	2.93
	C1	13"-24"	8.1	46847	29	35	36	10YR 5/6	clay loam	clay	Abudnant fragments	2.06
	C2	24"+	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		n/a
3	A1	0"-1"	n/a	n/a	n/a	n/a	n/a	10YR 3/2	n/a	loamy clay	Few fragments	n/a
	A2	1"-8"	8.1	43268	43	25	32	10YR 3/2	clay loam	clay	Abundant fragments	2.53

Continuation of Table 8: Soil data analysis summary from Texas A&M Soil, Water, and Forage Testing Laboratory.

Soil Pit	Horizon	Depth	pH	Calcium (ppm)	Sand %	Silt %	Clay %	Color Hue Value/Chroma	Lab Textural Class	Field Determined Textural Class	Rock Fragment Size and %	Organic Matter %
	A2/C1	8"-11"	8.2	45122	43	25	32	10 YR 4/2	clay loam	clay	Few Fragments	2.14
	C2	11"-16"	8.1	45956	29	27	44	2.5Y 6/4	clay	loamy clay to clay	Few fragments	4.11
	R[1]	16"-18"+	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Few fragments	n/a
4-East	A1	0"-3"	n/a	n/a	n/a	n/a	n/a	10YR 4/3	n/a	sandy loam	Few fragments	n/a
	R[1]	3"+	8.1	31991	44	24	32	10YR 4/3	clay loam	sandy clay loam	Abundant fragments	3.94
4-West	A1	0"-3"	n/a	n/a	n/a	n/a	n/a	10YR 4/3	n/a	sandy loam	Few fragements	n/a
	A2	3"-3.5"	n/a	n/a	n/a	n/a	n/a	10YR 4/3	n/a	sandy loam	a	n/a
	C	3.5"+	8	43689	47	22	31	10YR 4/3	sandy clay loam	sandy clay loam	Abundant fragments	3.57
5	A1	0"-2"	n/a	n/a	n/a	n/a	n/a	10YR 3/2	n/a	silty clay loam	Abundant fragments	n/a
	A2	2"-10"	8.1	31716	39	26	35	10YR 3/2	clay loam	silty clay	Few fragments	4.81
	R[1]	10"+	8.1	44850	45	22	33	10YR 3/2	clay loam	silty loam		2.99
6	A1	0"-1.5"	n/a	n/a	n/a	n/a	n/a	10YR 3/2	n/a	silty clay loam	a	n/a
	A2	1.5"-17"	8.2	35139	37	24	39	10YR 4/2	clay loam	silty clay	b	3.47
	R[1]	17"+	7.8	44131	43	24	33	10YR 4/2	clay loam	silty loam	c	2.65

[1] = Hard limestone

Rock Fragment Size and %:
a = ~25-30% grave; 10% cobble
b = ~20% micritic limestone cobbles; 5-10% gravel
c = >5% gravel present
d = Few gravel pieces present

A thin A1 horizon was observed in the field at all soil pits along the transect. Samples for this horizon were not submitted for laboratory analysis because of sample size. Texturally, subtle differences were observed in the field between horizons; however laboratory analysis classified most soils as clay loams. The barrens (SP4) contained the highest sand particle fraction, which seems to be mostly composed of miniscule limestone fragments. The hollow section of the seep (SP2) had the lowest sand particle concentration and the highest silt concentration. This is a logical result since excess water pools in this area due to the lack of porosity in the soils. Clay content was similar in all zones, reflecting derivation from clayey parent material.

The pH of the soils was relatively consistent, averaging 8, throughout the profiles, which is a result of the high carbonate concentration of the parent material. Slight differences in organic matter were observed between the soil pits. The western, lower half of the hillslope seep (SP1-West and SP2) had the lowest concentrations of organic matter. The eastern, higher half of the hillslope (SP1-East), the barrens (SP4), and the tallgrass zone (SP5 and SP6) had higher concentrations of organic matter.

Two geologic contact points were discovered along the transect. SP1, located on the hillslope portion of the seep, showed grading from in-place limestone on the east to deep marl on the west. Exposed limestone bedding was observed upslope of the hillslope seep and deeper soils were observed downslope at SP2. This supports the hypothesis that SP1 is a contact point between the marl and limestone layers. The second contact was discovered at SP4. In-place limestone on the east graded to deeper marls on the west, although the gradient was not as great as at SP1. Deeper soils observed at SP5 and SP6

combined with the contact point at SP1 suggest that SP4 is the downslope contact point between the marl and limestone layers.

The depth either to the R horizon, which was fractured limestone, or marl layer, designated as a C horizon, varied between zones. The soils of the lower portion of the hillslope and hollow were deeper than the soils of any other zone. The barrens (SP4) had the thinnest soil profile (3" to 3.5").

Laboratory analysis suggests the zones are a mixture of mollisols and inceptisols. Mollisols are dark (color value and chroma < 3), relatively thick soils with high organic content derived from development under prairie grasses (Soil Survey Staff 2010). The A horizons of mollic epipedons are 10" or greater and have > 0.6 percent organic carbon. Inceptisols, in comparison, are soils with minimal profile development and ochric epipedons (Soil Survey Staff 2010). Ochric soils are thin surface horizons that are too light in color, too high in chroma, and too thin to be mollic soils (Soil Survey Staff 2010). Entisols have little to no pedogenic horizon development and have no horizons other than an ochric epipedon. SP2, SP3, SP5, and SP6 possess mollic soil characteristics that border between mollisols and inceptisols since the color value and chroma for most of the soils is equal to 3. SP1-East, SP1-West, and the barrens (SP4) have developed A horizons less than 10", suggesting that these soils are inceptisols rather than entisols.

Wetlands Status

As previously stated, Muhly seep systems are not currently jurisdictional under the USACE. In order to be considered as such, Muhly seeps must meet the vegetation, soil, and hydrologic criteria outlined in the USACE Great Plains Regional Supplement (2010). Texas is covered by three regional supplements: The Arid West, the Atlantic and Gulf Coast, and the Great Plains, which encompasses North Texas.

Hydrophytic vegetation is defined by the USACE (2010) as the total of macrophytic plant life that occurs in areas where there is either permanent or periodically saturated soils for a period of that has a controlling influence on the plant species present. Common wetland plant species are assigned a wetlands indicator status code.

Using the 50/20 rule, it was determined that only select sections of the study site met the hydrophytic vegetation criterion (Figures 8 and 9). Figure 9 may be misleading. P16 corresponds with the barrens area of the study site and is dominated by *Tridens muticus,* a FACW* plant. The asterisks mean that this indicator status is currently under review. The barrens are characterized by shallow soils with xeric conditions and have many species, like *Opuntia phaecantha*, that cannot withstand saturated environments. It is postulated that *T. muticus* has been assigned an incorrect wetland code and may have been confused with the similar-looking *Tridens albescens*, which is found in seasaonlly wet swales adjacent to the study site.

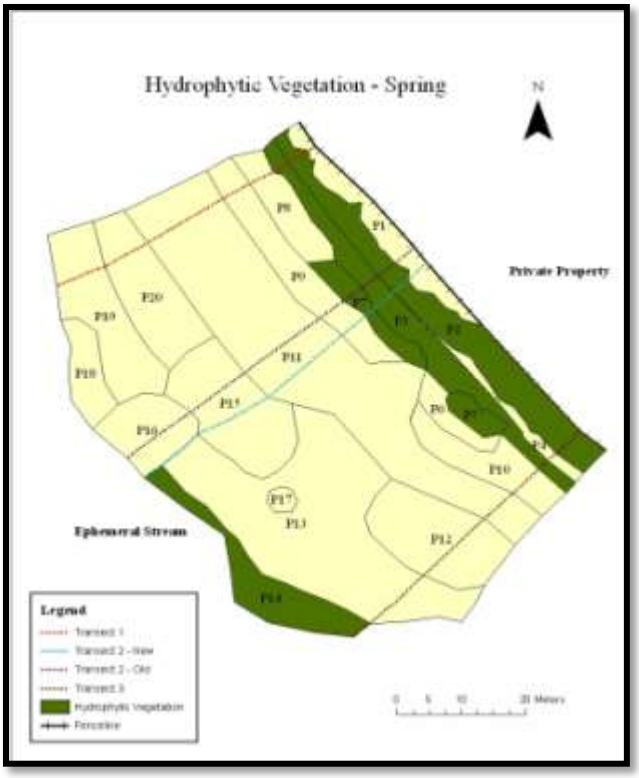

Figure 8: Hydrophytic vegetation location for spring. Green patches meet the hydrophytic vegetation criterion.

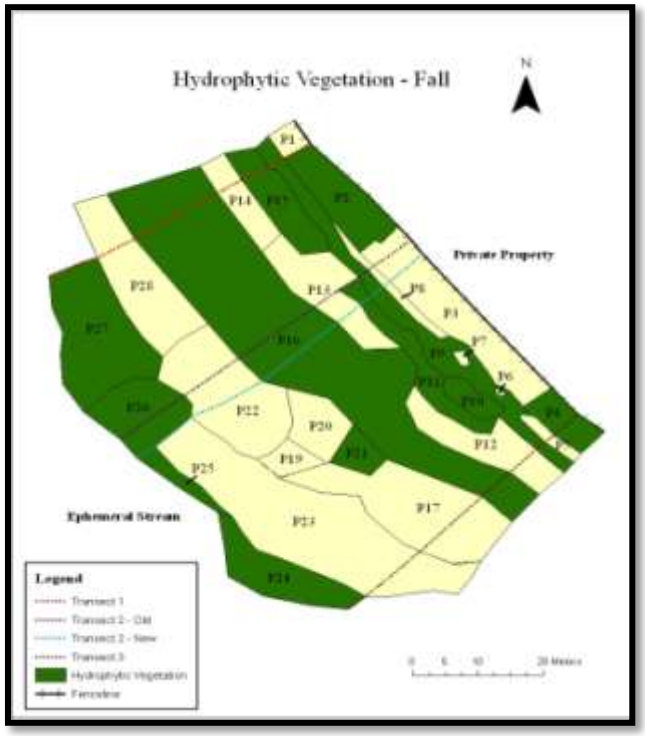

Figure 9: Hydrophytic vegetation location for fall. Green patches meet the hydrophytic vegetation criterion.

Saturated soils, or hydric soils, are one requirement for wetlands delineation. The anaerobic environment created by hydric soils affects many qualities of the soils and many hydric soils will have low chroma colors, be gray, exhibit mottling due to soil saturation, or possess oxidized root channels (USACE 2010). Identification of mollisols as hydric soils is problematic, however, because non-hydric mollisols also have a low chroma matrix (USACE 2010). While some oxidized root channels were present, other hydric soil indicators were absent, suggesting that these soils are not hydric.

VI. DISCUSSION

Vegetation

The characteristic plant species of Muhly seeps is *Muhlenbergia reverchonii*, which is consistently found at each of the study sites. However, this species is not restricted to hillslope seeps and is seen on nearby barrens and riparian areas as well. This complicates matters when trying to delineate a hillslope seep.

The *Muhlenbergia reverchonii – Carex microdonta – Eleocharis* species relationship is the only relationship common to all study sites. Three spring blooming perennials, *Carex microdonta*, *Eleocharis occulta*, and *Eleocharis montevidensis*, have been consistently associated with *M. reverchonii*, particularly in hollow or depression areas at the toe of hillslopes. The aboveground shoots of *E. occulta* and *E. montevidensis* are nearly indistinguishable in the field; they must be distinguished by their rhizomes. *Eleocharis occulta* has shorter, thicker rhizomes whose surfaces are completely concealed by bases of dead stems, hence the epithet 'occulta,' meaning hidden (Smith 2001).

The pedestrian-equestrian trail that runs through the hollow of the seep does not seem to affect the distribution of species like *C. microdonta*; however, it does appear to have an impact on *M. reverchonii* distribution. This may contribute to a lower-than-anticipated percentage of frequency seen during the spring and fall in the hollow.

The *Muhlenbergia reverchonii-Carex microdonta-Eleocharis* species association is similar to the *Muhlenbergia reverchonii-Bouteloua hirsuta* var. *pectinata-Carex microdonta* herbaceous association from NatureServe (2010) near Fort Hood, Bell County, Texas. The researchers on NatureServe found this community on seasonally

saturated, rocky slopes on Glen Rose Limestone within *Juniperus ashei* woodlands, which are similar to the seeps found in North Central Texas. Although woodlands were absent from the USACE site, Muhly seeps near *J. ashei* woodlands have been observed on prairies west of Benbrook Lake. *Juniperus ashei* is a fast spreading invasive species in North Central Texas and may eventually reach the USACE site.

Other relationships arose when examining just the USACE site. Aside from grasses like *M. reverchonii*, *Schizachyrium scoparium* and *Andropogon gerardii*, *Symphyotrichum ericoides* was the most widespread and frequently seen species throughout the study in both spring and fall. It was even the primary dominant species in the hollow section of the seep during the fall despite its FACU- status. The rhizomatous *S. ericoides* may have taken advantage of the very dry summer conditions and colonized the desiccated hollow area. The summer and fall of 2010 were two of the driest seasons in North Central Texas on record (Llado 2011).

During the spring, two thistle species, *Centaurea americana* and *Cirsium undulatum*, grew mixed with *M. reverchonii*. While these species were seen elsewhere in the study area, they were predominant on the hillslope section of the seep. They were generally absent from the deeper, wetter soils found in the hollow. *Cirsium undulatum* was also frequently seen mixed with *Andropogon gerardii* in more well-drained soils. These species were not seen at the other sites.

Several species restricted to the hollow section of the seep were seen during the spring and fall. Most notably, a dense cluster of *Juncus texanus* appeared in the hollow during the spring. The appearance of this obligate wetland plant may be due to excess water pooling in this area due to its abutment against a small berm along the pathway.

Allium cf. *runyonii* and *Marshallia caespitosa*, in the spring, and *Lippia nodiflora*, in the fall, were other unique species seen only in the hollow. Only a few stems of *Spiranthes* cf. *ovalis*, a very rare orchid species, were observed in the hollow of the slope during the fall. This particular species has not been seen in Texas since the 1960s (Diggs et al. 1999).

The associated barrens were dominated by a variety of asters during the spring, while during the fall, the barrens area shifted from a system primarily dominated by *M. reverchonii* to one dominated by *Tridens muticus*. This did not occur at the FWNCR and it is uncertain if this is a recurring phenomenon or a singular event unique to the USACE site in response to the dry summer. *Muhlenbergia reverchonii* was present during both seasons, indicating that it is not dependent on soil depth and can survive in areas of severe desiccation.

There was also a clear separation between *M. reverchonii* and areas dominated by *Schizachyrium scoparium* and *Andropogon gerardii*, the two most dominant tallgrass species present, indicating competitive exclusion. There were a few instances of intermixing but these generally occurred at the borders between the species and never extensively in large strands. As previously stated, this lack of intermixing is most likely caused by the characteristics of the species; *S. scoparium* and *A. gerardii* prefer deep, well-drained soils whereas *M. reverchonii* survives in hyperseasonal environments with both shallow and deep soils.

The LBJ Grasslands site was very different in vegetation, soil composition, and hydrology from the other sites. Many unique species were found at the LBJ Grasslands such as *Rhynchospora nivea*, *Fimbristylis puberula* var. *puberula*, and *Scleria*

verticillata, which has not been seen in North Central Texas since 1966 (Diggs et al. 1999). The sandy soils were very loose and easily erodible, which led to sparse vegetation, especially in the hollow of the seep. Also, the seep was consistently saturated, whereas in other sites the seeps were dry for a large part of the study. For the purposes of this study, this seep was not differentiated from the others; however, it may be warranted in the future to separate Muhly seeps with primarily sandy soils from those with primarily clay soils.

Pedology

Schizachyrium scoparium and *Andropogon gerardii*, the dominant species found in the tallgrass zones, are generally found in deep, well-drained soils (Dale 1959). In comparison, *Muhlenbergia reverchonii*, the dominant grass species on the hillslope seep, is found in environments that experience both mesic and xeric conditions. It was initially hypothesized that the differences in vegetation patches, specifically between the hillslope seep, the barrens, and tallgrass zones, were caused by significant differences in soil composition. Upon analysis, however, the lithology and the depth to the R horizon were the most significant differences between the zones.

Field observations suggest that several contacts between soil and the R horizon are paralithic rather than lithic. A lithic contact is the contact between soil and "a coherent underlying material," such as limestone, that is virtually continuous while a paralithic contact is between soil and paralithic materials that "have no cracks or the spacing of the cracks that roots can enter is 10 cm or more" (Soil Survey Staff 2010, 26). "Paralithic materials are relatively unaltered materials that have an extremely weakly cemented to moderately cemented rupture-resistance class" (Soil Survey Staff 2010, 26).

The marly horizons observed at SP1-West, SP5, and SP6 were labeled R rather than B because they were derived from clay-heavy paralithic parent material. After analysis of the hydrologic regime through all zones, it was determined that soil composition, because of its relative uniformity along the transect, does not have as large an impact on vegetation composition as the underlying geology. The differences in hydrologic regime between zones are more defined than those of the soils (Llado 2011).

Field analysis suggests that no hydric soils are present at the USACE site. However, since Muhly seeps are ephemeral systems by nature, there is a possibility that they may exhibit ephemerally hydric soils. Future analysis of soils should be done during the wet season validate this hypothesis.

Wetlands Status

Llado (2011) examined the hydrologic regime of Muhly seep systems and determined that only the hillslope seep at the USACE site met the hydrologic requirements for wetlands delineation. Hydrophytic vegetation prevalence shifted throughout the seasons, making it difficult to evaluate this criterion. The pedestrian-equestrian walkway, part of the hollow of the seep, appears to be one of the areas that meet the criterion for hydrophytic vegetation during both the spring and fall. This is not surprising given the tendency of the hollow to pool water. The results from individual patch cannot be applied to the entire zone, however, and it is suggested that the vegetation communities in a Muhly seep system are seasonally hydrophytic. The pedologic analysis yielded no hydric soils. Subsequently, Muhly seep systems are not jurisdictional (2010).

This combination of circumstances suggests that Muhly seep systems may be seasonally unstable ephemeral wetlands due to their hyperseasonal nature. This is a previously unrecognized wetland type. It may have significant implications for future wetlands delineation and may help protect endangered wetlands systems.

Future Research and Applications

The purpose of this study is to describe the vegetation and soils associated with Muhly seeps. While this study focused on relatively undisturbed seeps, one avenue of research would be to examine urban Muhly seep systems, such as the one located on the TCU campus. This particular seep was previously part of the Worth Hills Golf Course and is routinely mowed year-round (Burgess 2010b). From casual personal observation, *Carex microdonta* and an *Eleocharis* species have been observed in the hillslope hollow of the seep. However, *Muhlenbergia reverchonii* is noticeably absent. *Muhlenbergia reverchonii* was also minimally present along the pedestrian-equestrian pathway that ran through the hollow of the seep at the USACE site. However, Dale (1959) observed that many old building sites that were previously forested within Platt National Park later became dominated by *M. reverchonii*. Further analysis would need to be done to determine the effect of land disturbance on *M. reverchonii* distribution.

The current extent of Muhly seep systems is unknown. Casual observation suggests that approximately one to five percent, perhaps upwards to ten percent, of the prairie systems of North Central Texas may be composed of Muhly seeps. If this hypothesis is valid, then Muhly seep systems as a whole may have a signficiant impact on navigable waters, which would make them jurisdictional under the USACE. Future

research should focus on the identification and determination of the extent of Muhly seeps in order to understand their impact on navigable waters and prairie systems.

This study also has implications for translation research, particularly in the development of biofiltration swales, grey water filtration systems, and green roofs. Biofiltration swales, or bioswales, are relatively low cost vegetated channels that redirect runoff and remove pollutants from storm water. A bioswale may either be fully vegetated structure or an open channel or drainage system located next to an area of impervious surface no larger than five acres (Jurries 2003). Although this study does not examine water quality, Muhly seeps may potentially be useful as models for biofiltration swales since many seeps are found in depressions or hollows.

"Grey water is the wastewater collected separately from sewage flow from clothes washers, bathtubs, showers and sinks, but does not include wastewater from kitchen sinks, dishwashers, or toilets" (Al-Jayyousi 2003, 182). Although there are no definitive guidelines for grey water filtration systems, they should be hygienically safe, environmentally tolerable, and technically and economically feasible. Further studies into the capabilities of Muhly seeps to filter pollutants would need to be conducted.

Finally, the Muhly seep system may be beneficial to use as a model for green roof projects due to their hyperseasonal nature. A green roof consists of planting media and a plant system built on top of a building for a variety of reasons ranging from thermal insulation to stormwater filtration (Wark and Wark 2003). Since Muhly hillslope seeps can withstand periods of severe saturation and desiccation, it may be of importance especially in regions like North Texas that experience very wet springs followed by extremely dry summers.

VII. CONCLUSIONS

Muhly seeps are poorly understood systems endemic to Texas and Oklahoma. In addition to creating a description of the vegetation and soils associated with these systems, this study sought to establish toposequence relationships between vegetation and soils found on or near these systems and to determine if Muhly seeps fit the USACE definition of a wetland.

The *Muhlenbergia reverchonii-Carex microdonta-Elecoharis* species relationship was the only common association among all Muhly hillslope seeps. A similar relationship was observed near Fort Hood, Texas. Other relationships associated with the USACE site included the clear separation of *M. reverchonii* and *Schizachyrium scoparium* and *Andropogon gerardii* as well as the association between *M. reverchonii* and *Centaurea americana* and *Cirsium undulatum* on the hillslope seep.

Although certain sections of the Muhly hillslope seep at the USACE site met the hydrophytic vegetation and hydrologic criteria, it failed to meet the pedologic requirements (Llado 2011). Muhly seep systems are consequently not jurisdictional under the USACE. However, due to the hyperseasonal nature of Muhly seeps, they may be classified as a previously unrecognized ephemeral wetland, or hyperseasonal wetland, and may lead to the discovery of other ephermal systems.

The exact extent of Muhly seep systems is unknown and it is uncertain if these systems are endangered. Casual observation suggests that Muhly seeps compose upwards of ten percent of the prairie ecosystems in North Central Texas. If Muhly seeps are ephemeral wetlands, their wide distribution may potentially have signficiant impacts on navigable waters. The findings of this study will not only provide a guide for future

Muhly seep identification but hopefully will increase conservation of these previously unrecognized ephemeral wetland systems.

APPENDICES

APPENDIX A

SPECIES LIST

APPENDIX A: SPECIES LIST

Table 1: List of species identified during the study sorted by family. Species and vernacular names and wetland indicator statuses are from the USDA PLANTS Database (2011) and verified against Reed (1988). Wetland indicator statues are specific for Region 6. Synonyms are from Diggs et al. (1999).

Family	Species Name	Vernacular Name	Wetland Indicator Status	Synonyms
Acanthaceae	*Dyschoriste linearis* (Torr. & A. gray) Kuntze	Polkadots	NI	
Acanthaceae	*Ruellia humilis* Nutt.	Fringeleaf wild petunia	FAC-	
Agavaceae	*Yucca arkansana* Trel.	Arkansas yucca	NI	
Agavaceae	*Yucca pallida* McKelvey	Twistleaf yucca	NI	
Apiaceae	*Bifora americana* Benth. & Hook. f. ex S. Watson	Prairie bishop	NI	
Apiaceae	*Eryngium leavenworthii* Torr. & A. Gray	Leavenworth's eryngo	NI	
Apiaceae	*Polytaenia nuttallii* DC.	Nuttall's prairie parsley	NI	
Apiaceae	*Torilis arvensis* (Huds.) Link	Spreading hedgeparsley	NI	
Apocynaceae	*Amsonia ciliata* Walter var. *texana* (A. Gray) J.M. Coult.	Fringed bluestar	NI	
Asclepiadaceae	*Asclepias asperula* (Decne.) Woodson	Spider milkweed	NI	
Asclepiadaceae	*Asclepias stenophylla* A. Gray	Slimleaf milkweed	NI	
Asteraceae	*Ambrosia trifida* L.	Great ragweed	FAC	
Asteraceae	*Artemisia ludoviciana* Nutt.	White sagebrush	UPL	
Asteraceae	*Centaurea americana* Nutt.	American star-thistle	NI	
Asteraceae	*Cirsium undulatum* (Nutt.) Spreng.	Wavyleaf thistle	FACU	
Asteraceae	*Croptilon divaricatum* (Nutt.) Raf.	Slender scratchdaisy	FACU	
Asteraceae	*Dracopis amplexicaulis* (Vahl) Cass.	Clasping coneflower	FAC+	
Asteraceae	*Dysodiopsis tagetoides* (Torr. & A. Gray) Rydb.	False dogfennel	NI	
Asteraceae	*Engelmannia peristenia* (Raf.) Goodman & C.A. Lawson	Engelmann's daisy	NI	
Asteraceae	*Euthamia gymnospermoides* Greene	Texas goldentop	FAC+/NO[1]	
Asteraceae	*Gaillardia aestivalis* var. *flavovirens* (C. Mohr) Cronquist	Lanceleaf blanketflower	NI	
Asteraceae	*Gaillardia pulchella* Foug.	Firewheel	NI	
Asteraceae	*Gutierrezia texana* (DC.) Torr. & A. Gray	Texas snakeweed	NI	

Continuation of Table 1: List of species identified during the study sorted by family.

Family	Species Name	Vernacular Name	Wetland Indicator Status	Synonyms
Asteraceae	*Helianthus annuus* L.	Common sunflower	FAC	
Asteraceae	*Helianthus maximiliani* Schrad.	Maximilian sunflower	FACU-	
Asteraceae	*Iva angustifolia* Nutt. ex DC.	Narrowleaf marsh elder	NI	
Asteraceae	*Liatris aestivalis* G.L. Nesom & R. O'Kennon	N/A	NI	
Asteraceae	*Liatris glandulosa* G.L. Nesom & R. O'Kennon	Glandular blazing star	NI	
Asteraceae	*Lindheimera texana* A. Gray & Engelm.	Texas yellowstar	NI	
Asteraceae	*Lygodesmia texana* (Torr. & A. Gray) Greene	Texas skeletonplant	NI	
Asteraceae	*Marshallia caespitosa* Nutt. ex DC.	Puffballs	FAC	
Asteraceae	*Packera tampicana* (DC.) C. Jeffrey	Great Plains ragwort	NI	
Asteraceae	*Palafoxia callosa* (Nutt.) Torr. & A. Gray	Small palafox	NI	
Asteraceae	*Rudbeckia hirta* L.	Blackeyed Susan	FACU	
Asteraceae	*Symphyotrichum ericoides* (L.) G.L. Nesom	White heath aster	FACU-	
Asteraceae	*Tetraneuris linearifolia* (Hook.) Greene	Fineleaf fournerved daisy	NI	
Asteraceae	*Thelesperma filifolium* (Hook.) A. Gray var. *filifolium*	Stiff greenthread	NI	
Boraginaceae	*Heliotropium tenellum* (Nutt.) Torr	Pasture heliotrope	NI	
Boraginaceae	*Lithospermum incisum* (Lehm.)	Narrowleaf stoneseed	NI	
Brassicaceae	*Lepidium austrinum* (Small)	Southern pepperwort	NI	
Brassicaceae	*Lesquerella engelmannii* (A. Gray) S. Watson	Engelmann's bladderpod	NI	
Cactaceae	*Opuntia phaeacantha* Engelm.	Tulip prickly pear	NI	
Convolvulaceae	*Evolvulus nuttallianus* Schult.	Shaggy dwarf morning-glory	NI	
Cyperaceae	*Bulbostylis capillaries* (L.) Kunth ex C.B. Clarke	Densetuft hairsedge		
Cyperaceae	*Carex microdonta* Torr. & Hook.	Littletooth sedge	OBL	
Cyperaceae	*Cenchrus spinifex* Cav.	Coastal sandbur	NI	
Cyperaceae	*Eleocharis montevidensis* Kunth	Sand spikerush	FACW+	
Cyperaceae	*Eleocharis occulta* S.G. Sm.	Limestone spikerush	OBL[2]	
Cyperaceae	*Fimbristylis puberula* (Michx.) Vahl var. *puberula*	Hairy fimbry	FACW	
Cyperaceae	*Juncus interior* Wiegand	Inland rush	FAC	
Cyperaceae	*Juncus tenuis* Willd.	Poverty rush	FAC	
Cyperaceae	*Juncus texanus* (Engelm.) Coville	Texas rush	OBL	
Cyperaceae	*Rhynchospora nivea* Boeckeler	Showy whitetop	FACW+	

Continuation of Table 1: List of species identified during the study sorted by family.

Family	Species Name	Vernacular Name	Wetland Indicator Status	Synonyms
Cyperaceae	*Scleria verticillata* Muhl. ex Willd.	Low nutrush	OBL	
Ebenaceae	*Diospyros virginiana* L.	Common persimmon	FAC	
Euphorbiaceae	*Chamaesyce missurica* (Raf.) Shinners	Prairie sandmat	NI	
Euphorbiaceae	*Croton monanthogynus* Michx.	Prairie tea	NI	
Euphorbiaceae	*Stillingia texana*I.M. Johnst.	Texas toothleaf	NI	
Fabaceae	*Medicago lupulina* L.	Black medick	FAC	
Fabaceae	*Mimosa nuttalli* (DC. ex Britton & Rose) B.L. Turner	Nuttall's sensitive-briar	NI	
Fabaceae	*Mimosa roemeriana* Scheele	Roemer's mimosa	NI	
Fabaceae	*Neptunia lutea* (Leavenworth) Benth.	Yellow puff	FACU	
Fabaceae	*Pediomelum linearifolium* (Torr. & A. Gray) J. Grimes	Narrowleaf Indian breadroot	NI	
Fabaceae	*Psoralidium tenuiflorium* (Pursch) Rydb.	Slimflower scrufpea	NI	
Fabaceae	*Senna roemeriana* (Scheele) Irwin & Barneby	Twoleaf senna	NI	
Fabaceae	*Tephrosia virginiana* (L.) Pers.	Virginia tephrosia	NI	
Gentianaceae	*Centaurium beyrichii* (Torr. & A. Gray ex Torr.) B.L. Rob.	Quinineweed	FACU	
Iridaceae	*Sisyrinchium angustifolium* Mill.	Narrowleaf blue-eyed grass	FACW-	
Krameriaceae	*Krameria lanceolata* Torr.	Trailing krameria	NI	
Lamiaceae	*Hedeoma acinoides* Scheele	Slender false pennyroyal	NI	
Lamiaceae	*Hedeoma reverchonii* (A. Gray) A. Gray var. *reverchonii*	Reverchon's false pennyroyal	NI	
Lamiaceae	*Monarda citriodora* Cerv. ex Lag.	Lemon beebalm	NI	
Lamiaceae	*Salvia farinacea* Benth.	Mealycup sage	NI	
Lamiaceae	*Salvia texana* (Scheele) Torr.	Thomas' sage	NI	
Lamiaceae	*Scutellaria wrightii* A. Gray	Wright's skullcap	NI	
Lamiaceae	*Teucrium canadense* L.	Canada germander	FACW-	
Lamiaceae	*Trichostema dichotomum* L.	Forked bluecurls	NI	
Lamiaceae	*Warnockia scutellarioides* M.W. Turner	Prairie brazosmint	NI	
Liliaceae	*Allium* cf. *runyonii* Ownbey	Runyon's onion	NI	
Linaceae	*Linum rigidum* Pursh var. *rigidum*	Stiffstem flax	NI	
Linaceae	*Linum sulcatum* Riddell	Grooved flax	NI	
Lythraceae	*Lythrum californicum* Torr. & A. Gray	California loosestrife	OBL	

Continuation of Table 1: List of species identified during the study sorted by family.

Family	Species Name	Vernacular Name	Wetland Indicator Status	Synonyms
Malvaceae	*Callirhoe digitata* Nutt.	Winecup	NI	
Malvaceae	*Callirhoe pedata* (Nutt. ex Hook.) A. Gray	Palmleaf poppymallow	NI	
Onagraceae	*Calylophus berlandieri* Spach subsp. *pinifolius* (Engelm. A. Gray) Shinners	Berlandier's sundrops	NI	
Onagraceae	*Gaura longiflora* Spach	Longflower beeblossom	NI	
Onagraceae	*Gaura suffulta* Engelm. ex A. Gray	Kisses	NI	
Onagraceae	*Stenosiphon linifolius* (Nutt. ex James) Heynh.	False gaura	NI	
Orchidaceae	*Spiranthes* cf. *ovalis* Lindl.	October lady's tresses	FAC	
Plantaginaceae	*Plantago patagonica* Jacq.	Woolly plantain	FACU-	
Plantaginaceae	*Plantago wrightiana* Decne.	Wright's plantain	NI	
Poaceae	*Andropogon gerardii* Vitman	Big bluestem	FACU	
Poaceae	*Bothriochloa ischaemum* (L.) Keng	Yellow bluestem	NI	
Poaceae	*Bothriochloa laguroides* (DC.) Herter	Silver beardgrass	NI	
Poaceae	*Bouteloua hirsuta* Lag. var. *hirsuta*	Hairy gramma	NI	
Poaceae	*Bromus arvensis* L.	Field brome	FACU	*Bromus japonicus*
Poaceae	*Bromus racemosus* L.	Bald brome	NI	*Bromus commutatus*
Poaceae	*Dichanthelium acuminatum* (Sw.) Gould & C.A. Clark var. *lindheimeri* (Nash) Gould & C.A. Clark	Lindheimer panicgrass	FAC	
Poaceae	*Dichanthelium oligosanthes* Schult.) Gould var. *scribnerianum* (Nash) Gould	Scribner's rosette grass	FACU	
Poaceae	*Elymus canadensis* L.	Canada wildrye	FAC+	
Poaceae	*Eragrostis curtipedicellata* Buckley	Gummy lovegrass	NI	
Poaceae	*Muhlenbergia reverchonii* Vasey & Scribn.	Seep Muhly grass	FAC	
Poaceae	*Nassella leucotricha* (Trin. & Rupr.) Pohl	Texas wintergrass	NI	
Poaceae	*Phalaris caroliniana* Walter	Carolina canarygrass	FACW	
Poaceae	*Schizachyrium scoparium* (Michx.) Nash	Little bluestem	FACU+	
Poaceae	*Sorghastrum nutans* (L.) Nash	Indiangrass	FACU	

Continuation of Table 1: List of species identified during the study sorted by family.

Family	Species Name	Vernacular Name	Wetland Indicator Status	Synonyms
Poaceae	*Sporobolus compositus* (Poir.) Merr. var. *drummondii* (Trin.) Kartesz & Gandhi	Drummond's dropseed	NI	
Poaceae	*Tridens muticus* (Torr.) Nash	Slim tridens	FACW*	
Polygalaceae	*Polygala alba* Nutt.	White milkwort	NI	
Rhamnaceae	*Ceanothus americanus* L.	New Jersey tea	NI	
Rosaceae	*Rosa foliolosa* Nutt. ex Torr. & A. Gray	White prairie rose	NI	
Rosaceae	*Rubus fruticosus* L. [excluded]	Shrubby blackberry	NI	
Rosaceae	*Rubus oklahomus* L.H. Bailey	Oklahoma blackberry	FAC	
Rubiaceae	*Galium virgatum* A. Gray	Southwestern bedstraw	NI	
Rubiaceae	*Hedyotis nigricans* (Lam.) Fosberg	Diamondflowers	NI	
Scrophulariaceae	*Agalinis heterophylla* (Nutt.) Small ex Britton	Prairie false foxglove	FAC	
Scrophulariaceae	*Castilleja indivisa* Engelm.	Entireleaf Indian paintbrush	FAC-	
Smilacaceae	*Smilax bona-nox* L.	Saw greenbrier	FAC	
Solanaceae	*Solanum dimidiatum* Raf.	Western horsenettle	NI	
Valerianaceae	*Valerianella amarelle* (Lindh. ex Engelm.) Krok	Hairy cornsalad	NI	
Verbenaceae	*Glandularia pumila* (Rydb.) Umber	Pink mock vervain	NI	
Verbenaceae	*Lippia nodiflora* (L.) Michx.	Turkey tangle frogfruit	FACW	

* Under review.
[1] Dependent on species.
[2] Suggested indicator status.

APPENDIX B

QUADRAT DATA

APPENDIX B: QUADRAT DATA

Table 1 shows the data for each quadrat sampled during the spring. Table 2 shows the data for each quadrat sampled during the fall. Each table is sorted by patch association and quadrat. The quadrat name is indicative of the location and order in which it was sampled. For instance, USACE-SP1Q1 would mean that it was sampled at the USACE site during spring (S) in patch (P) 1 quadrat (Q) 1. Within each quadrat, the species are ordered first by cover class and then alphabetically. Wetland indicator statuses were obtained from the USDA PLANTS Database (2008).

Table 1: Quadrat data for spring sampling period.

Spring Quadrat Data			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP1Q1	*Sporobolus compositus* var. *drummondii*	5	NI
	Centaurea americana	1	NI
	Symphyotrichum ericoides	1	FACU-
	Carex microdonta	1	OBL
	Iva angustifolia	+	NI
	Cirsium undulatum	r	FACU
	Dichanthelium acuminatum var. *lindheimeri*	r	FAC
USACE - SP1Q2	*Sporobolus compositus* var. *drummondii*	4	NI
	Carex microdonta	3	OBL
	Lythrum californicum	2	OBL
	Centaurea americana	2	NI
	Galium virgatum	+	NI
	Bifora americana	r	NI
	Eleocharis montevidensis	r	FACW+
	Symphyotrichum ericoides	r	FACU-
USACE - SP1Q3	*Centaurea americana*	6	NI
	Bifora americana	1	NI
	Carex microdonta	1	OBL
	Cirsium undulatum	1	FACU
	Eleocharis montevidensis	1	FACW+
	Lythrum californicum	1	OBL
	Plantago patagonica	+	FACU-
	Galium virgatum	r	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP1Q4	*Muhlenbergia reverchonii*	6	FAC
	Eleocharis montevidensis	3	FACW+
	Centaurea americana	2	NI
	Galium virgatum	1	NI
	Bifora americana	+	NI
	Bromus arvensis	+	NI
USACE - SP1Q5	*Carex microdonta*	5	OBL
	Sporobolus compositus var. *drummondii*	5	NI
	Symphyotrichum ericoides	2	FACU-
	Centaurea americana	1	NI
	Cirsium undulatum	1	FACU
	Bifora americana	1	NI
	Dichanthelium acuminatum var. *lindheimeri*	r	FAC
USACE - P1Q6	*Centaurea americana*	5	NI
	Iva angustifolia	3	NI
	Teucrium canadense	2	FACW-
	Bifora americana	1	NI
	Carex microdonta	1	OBL
	Cirsium undulatum	1	FACU
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - SP1Q7	*Centaurea americana*	4	NI
	Muhlenbergia reverchonii	4	FAC
	Teucrium canadense	4	FACW-
	Bromus arvensis	1	NI
	Carex microdonta	1	OBL
	Cirsium undulatum	1	FACU
	Iva angustifolia	1	NI
	Galium virgatum	r	NI
	Lythrum californicum	+	OBL
USACE - SP1Q8	Bare ground	3	
	Muhlenbergia reverchonii	5	FAC
	Cirsium undulatum	2	FACU
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	1	OBL
	Centaurea americana	1	NI
USACE - SP2Q1	*Muhlenbergia reverchonii*	5	FAC
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Sporobolus compositus var. *drummondii*	2	NI
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	1	OBL

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP2Q1	*Eleocharis montevidensis*	1	FACW+
	Iva angustifolia	1	NI
USACE - SP2Q2	*Muhlenbergia reverchonii*	6	FAC
	Ambrosia trifida	1	FAC
	Carex microdonta	1	OBL
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Eleocharis montevidensis	1	FACW+
	Mimosa roemeriana	1	NI
	Sporobolus compositus var. *drummondii*	1	NI
	Iva angustifolia	+	NI
USACE - SP2Q3	*Muhlenbergia reverchonii*	5	FAC
	Monarda citriodora	2	NI
	Carex microdonta	1	OBL
	Mimosa roemeriana	1	NI
	Symphyotrichum ericoides	1	FACU-
	Cirsium undulatum	+	FACU
	Dracopis amplexicaulis	+	FAC+
	Galium virgatum	r	NI
USACE - SP2Q4	*Ruellia humilis*	4	FAC-
	Ambrosia trifida	4	FAC
	Centaurea americana	2	NI
	Symphyotrichum ericoides	2	FACU-
	Ambrosia trifida	1	FAC
	Bifora americana	1	NI
USACE - SP2Q5	*Muhlenbergia reverchonii*	5	FAC
	Bare ground	3	
	Bromus arvensis	2	NI
	Ruellia humilis	2	FAC-
	Symphyotrichum ericoides	2	FACU-
	Schizachyrium scoparium	+	FACU+
USACE - SP2Q6	*Muhlenbergia reverchonii*	6	FAC
	Carex microdonta	2	OBL
	Bromus arvensis	1	NI
	Centaurea americana	1	NI
	Ambrosia trifida	+	FAC
USACE - SP2Q7	*Muhlenbergia reverchonii*	5	FAC
	Symphyotrichum ericoides	2	FACU-
	Bifora americana	1	NI
	Carex microdonta	1	OBL
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Eleocharis montevidensis	1	FACW+

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP2Q7	*Ruellia humilis*	1	FAC-
	Centaurea americana	+	NI
	Teucrium canadense	+	FACW-
USACE - SP2Q8	*Muhlenbergia reverchonii*	5	FAC
	Carex microdonta	3	OBL
	Iva angustifolia	2	NI
	Symphyotrichum ericoides	2	FACU-
	Ambrosia trifida	1	FAC
	Eleocharis montevidensis	1	FACW+
	Bifora americana	+	NI
	Schizachyrium scoparium	r	FACU+
USACE - SP2Q9	*Schizachyrium scoparium*	5	FACU+
	Hedeoma reverchonii var. *reverchonii*	3	NI
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Symphyotrichum ericoides	1	FACU-
	Bromus arvensis	+	NI
	Carex microdonta	+	OBL
	Sporobolus compositus var. *drummondii*	r	NI
USACE - SP2Q10	*Muhlenbergia reverchonii*	5	FAC
	Carex microdonta	3	OBL
	Symphyotrichum ericoides	2	FACU-
USACE - SP3Q1	*Carex microdonta*	4	OBL
	Lythrum californicum	3	OBL
	Marshallia caespitosa	1	FAC
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - SP3Q2	*Muhlenbergia reverchonii*	5	FAC
	Carex microdonta	2	OBL
	Eleocharis montevidensis	2	FACW+
	Juncus texanus	2	OBL
	Dichanthelium acuminatum subsp. lindheimeri	1	FAC
	Sisyrinchium angustifolium	+	FACW-
	Lythrum californicum	r	OBL
USACE - SP3Q3	*Eleocharis montevidensis*	4	FACW+
	Bare ground	2	
	Muhlenbergia reverchonii	2	FAC
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Juncus texanus	1	OBL
	Tridens muticus	1	FACW
	Carex microdonta	+	OBL
	Symphyotrichum ericoides	+	FACU-

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP3Q4	*Eleocharis montevidensis*	4	FACW+
	Carex microdonta	3	OBL
	Symphyotrichum ericoides	2	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Juncus texanus	1	OBL
	Centaurea americana	Dead	NI
USACE - SP3Q5	*Eleocharis montevidensis*	3	FACW+
	Muhlenbergia reverchonii	3	FAC
	Bare ground	3	
	Carex microdonta	2	OBL
	Juncus texanus	1	OBL
	Symphyotrichum ericoides	1	FACU-
	Lythrum californicum	1	OBL
USACE - SP3Q6	*Teucrium canadense*	3	FACW-
	Bare ground	2	
	Carex microdonta	2	OBL
	Dichanthelium acuminatum subsp. lindheimeri	2	FAC
	Schizachyrium scoparium	2	FACU+
	Symphyotrichum ericoides	2	FACU-
	Iva angustifolia	1	NI
	Juncus texanus	1	OBL
	Lythrum californicum	+	OBL
	Sisyrinchium angustifolium	r	FACW-
USACE - SP4Q1	*Symphyotrichum ericoides*	5	FACU-
	Carex microdonta	2	OBL
	Sporobolus compositus var. *drummondii*	2	NI
	Iva angustifolia	1	NI
	Bromus arvensis	+	NI
	Ambrosia trifida	+	FAC
	Mimosa roemeriana	+	NI
	Monarda citriodora	r	NI
USACE - SP4Q2	*Symphyotrichum ericoides*	5	FACU-
	Plantago patagonica	3	FACU-
	Bromus arvensis	2	NI
	Monarda citriodora	2	NI
USACE - SP4Q3	*Symphyotrichum ericoides*	5	FACU-
	Bromus arvensis	2	NI
	Hedyotis nigricans	2	NI
	Monarda citriodora	2	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP4Q3	*Hedyotis nigricans*	+	NI
	Centaurea americana	r	NI
USACE - SP4Q4	*Symphyotrichum ericoides*	4	FACU-
	Bare ground	3	
	Gaillardia pulchella	2	NI
	Monarda citriodora	2	NI
	Ambrosia trifida	1	FAC
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Bromus arvensis	+	NI
	Calylophus berlandieri subsp. *pinifolius*	+	NI
	Centaurea americana	+	NI
	Dracopis amplexicaulis	+	FAC+
	Plantago patagonica	+	FACU-
	Cirsium undulatum	r	FACU
USACE - SP4Q5	*Ambrosia trifida*	5	FAC
	Hedyotis nigricans	2	NI
	Bromus arvensis	+	NI
	Monarda citriodora	+	NI
USACE - SP4Q6	*Ambrosia trifida*	5	FAC
	Bare ground	3	
	Symphyotrichum ericoides	3	FACU-
	Hedyotis nigricans	3	NI
	Bifora americana	+	NI
USACE - SP4Q7	*Ambrosia trifida*	3	FAC
	Symphyotrichum ericoides	3	FACU-
	Hedyotis nigricans	3	NI
	Monarda citriodora	2	NI
	Bromus arvensis	1	NI
	Gaillardia pulchella	+	NI
	Bromus arvensis	+	NI
USACE - SP5Q1	*Juncus texanus*	5	OBL
	Iva angustifolia	3	NI
	Symphyotrichum ericoides	+	FACU-
	Cirsium undulatum	r	FACU
	Dracopis amplexicaulis	r	FAC+
USACE - SP5Q2	*Juncus texanus*	6	OBL
	Monarda citriodora	2	NI
	Iva angustifolia	1	NI
	Dracopis amplexicaulis	+	FAC+
USACE - SP5Q3	*Juncus texanus*	5	OBL
	Iva angustifolia	4	NI
	Dracopis amplexicaulis	+	FAC+

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP5Q4	*Juncus texanus*	5	OBL
	Iva angustifolia	3	NI
	Bromus arvensis	+	NI
	Symphyotrichum ericoides	+	FACU-
USACE - SP5Q5	*Juncus texanus*	6	OBL
	Iva angustifolia	+	NI
	Bromus arvensis	r	NI
USACE - SP6Q1	*Monarda citriodora*	5	NI
	Gaillardia pulchella	2	NI
	Solanum dimidiatum	2	NI
	Bromus arvensis	1	NI
	Centaurea americana	1	NI
	Symphyotrichum ericoides	1	FACU-
	Bifora americana	+	NI
USACE - SP6Q2	*Monarda citriodora*	4	NI
	Bromus arvensis	2	NI
	Symphyotrichum ericoides	2	FACU-
	Dracopis amplexicaulis	1	FAC+
	Juncus tenuis	+	FAC
	Phalaris caroliniana	+	FACW
USACE - SP6Q3	*Symphyotrichum ericoides*	4	FACU-
	Carex microdonta	2	OBL
	Monarda citriodora	2	NI
	Bromus arvensis	1	NI
	Dracopis amplexicaulis	1	FAC+
	Iva angustifolia	1	NI
USACE - SP6Q4	*Ambrosia trifida*	4	FAC
	Iva angustifolia	4	NI
	Symphyotrichum ericoides	3	FACU-
	Dracopis amplexicaulis	2	FAC+
	Phalaris caroliniana	+	FACW
USACE - SP6Q5	*Ambrosia trifida*	5	FAC
	Iva angustifolia	2	NI
	Dracopis amplexicaulis	1	FAC+
	Bifora americana	+	NI
	Phalaris caroliniana	+	FACW
USACE - SP7Q1	*Carex microdonta*	3	OBL
	Lythrum californicum	3	OBL
	Symphyotrichum ericoides	3	FACU-
	Iva angustifolia	1	NI
	Bifora americana	+	NI
	Centaurea americana	+	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP7Q1	*Marshallia caespitosa*	+	FAC
USACE - SP7Q2	*Lythrum californicum*	3	OBL
	Ambrosia trifida	2	FAC
	Carex microdonta	1	OBL
	Iva angustifolia	+	NI
	Symphyotrichum ericoides	+	FACU-
USACE - SP7Q3	*Schizachyrium scoparium*	6	FACU+
	Carex microdonta	1	OBL
	Symphyotrichum ericoides	1	FACU-
	Bromus arvensis	+	NI
	Monarda citriodora	r	NI
USACE - SP7Q4	*Sorghastrum nutans*	4	NI
	Symphyotrichum ericoides	3	FACU-
	Bifora americana	1	NI
	Carex microdonta	1	OBL
	Lythrum californicum	+	OBL
	Solanum dimidiatum	+	NI
	Iva angustifolia	r	NI
	Plantago patagonica	r	FACU-
USACE - SP7Q5	*Sorghastrum nutans*	4	NI
	Carex microdonta	2	OBL
	Solanum dimidiatum	2	NI
	Lythrum californicum	1	OBL
	Ambrosia trifida	+	FAC
	Iva angustifolia	+	NI
	Monarda citriodora	+	NI
	Phalaris caroliniana	+	FACW
USACE - SP7Q6	*Schizachyrium scoparium*	4	FACU+
	Symphyotrichum ericoides	4	FACU-
	Monarda citriodora	2	NI
	Carex microdonta	1	OBL
	Iva angustifolia	1	NI
	Lythrum californicum	1	OBL
	Marshallia caespitosa	+	FAC
USACE - SP7Q7	*Schizachyrium scoparium*	5	FACU+
	Symphyotrichum ericoides	2	FACU-
	Hedyotis nigricans	1	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Lythrum californicum	+	OBL
USACE - SP7Q8	*Muhlenbergia reverchonii*	3	FAC
	Carex microdonta	3	OBL

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP7Q8	*Lythrum californicum*	2	OBL
	Iva angustifolia	1	NI
	Schizachyrium scoparium	1	FACU+
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - SP7Q9	*Muhlenbergia reverchonii*	5	FAC
	Carex microdonta	2	OBL
	Eleocharis montevidensis	1	FACW+
	Lythrum californicum	1	OBL
	Symphyotrichum ericoides	1	FACU-
USACE - SP7Q10	*Sorghastrum nutans*	5	NI
	Carex microdonta	2	OBL
	Eleocharis montevidensis	2	FACW+
	Bromus arvensis	1	NI
	Lythrum californicum	1	OBL
	Ambrosia trifida	r	FAC
USACE - SP8Q1	*Andropogon gerardii*	6	FACU
	Centaurea americana	2	NI
	Monarda citriodora	2	NI
	Ambrosia trifida	1	FAC
	Bifora americana	+	NI
	Bromus arvensis	+	NI
USACE - SP8Q2	*Andropogon gerardii*	6	FACU
	Symphyotrichum ericoides	1	FACU-
	Ambrosia trifida	+	FAC
USACE - SP8Q3	*Andropogon gerardii*	6	FACU
	Monarda citriodora	2	NI
	Bifora americana	1	NI
	Symphyotrichum ericoides	1	FACU-
USACE - SP9Q1	*Ambrosia trifida*	4	FAC
	Symphyotrichum ericoides	4	FACU-
	Schizachyrium scoparium	2	FACU-
	Hedeoma reverchonii var. *reverchonii*	1	NI
	Hedyotis nigricans	1	NI
	Schizachyrium scoparium	1	FACU-
	Bromus arvensis	r	NI
USACE - SP9Q2	*Ambrosia trifida*	3	FAC
	Hedyotis nigricans	3	NI
	Schizachyrium scoparium	3	FACU-
	Bifora americana	1	NI
	Hedeoma reverchonii var. *reverchonii*	1	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP9Q3	*Ambrosia trifida*	5	FAC
	Gaillardia pulchella	2	NI
	Bifora americana	1	NI
	Symphyotrichum ericoides	1	FACU-
	Andropogon gerardii	+	FACU
	Hedeoma reverchonii var. *reverchonii*	+	NI
	Plantago patagonica	+	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	r	FAC
	Gaura suffulta	r	NI
USACE - SP9Q4	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	3	FAC
	Hedyotis nigricans	2	NI
	Mimosa roemeriana	2	NI
	Bifora americana	+	NI
USACE - SP9Q5	*Schizachyrium scoparium*	4	FACU-
	Symphyotrichum ericoides	2	FACU-
	Bromus arvensis	+	NI
	Cirsium undulatum	+	FACU
USACE - SP9Q6	*Schizachyrium scoparium*	6	FACU-
	Centaurea americana	1	NI
	Mimosa roemeriana	+	NI
	Dichanthelium acuminatum var. *lindheimeri*	+	FAC
	Amsonia ciliata	r	NI
USACE - SP9Q7	*Schizachyrium scoparium*	5	FACU-
	Monarda citriodora	3	NI
	Ambrosia trifida	2	FAC
	Bromus arvensis	1	NI
USACE - SP9Q8	*Hedyotis nigricans*	4	NI
	Schizachyrium scoparium	3	FACU-
	Monarda citriodora	2	NI
	Ruellia humilis	+	FAC-
USACE - SP9Q9	*Hedyotis nigricans*	4	NI
	Symphyotrichum ericoides	3	FACU-
	Schizachyrium scoparium	1	FACU-
	Monarda citriodora	+	NI
	Centaurea americana	r	NI
USACE - SP9Q10	*Schizachyrium scoparium*	4	FACU-
	Hedyotis nigricans	2	NI
	Symphyotrichum ericoides	1	FACU-
	Cirsium undulatum	+	FACU

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP9Q11	*Hedyotis nigricans*	4	NI
	Schizachyrium scoparium	2	FACU-
	Centaurea americana	1	NI
	Schizachyrium scoparium	1	FACU-
USACE - SP9Q12	*Monarda citriodora*	3	NI
	Schizachyrium scoparium	3	FACU-
	Bromus arvensis	2	NI
	Hedyotis nigricans	2	NI
USACE - SP10Q1	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	2	FAC
	Bifora americana	+	NI
USACE - SP10Q2	*Schizachyrium scoparium*	6	FACU-
	Bifora americana	+	NI
USACE - SP10Q3	*Symphyotrichum ericoides*	4	FACU-
	Schizachyrium scoparium	3	FACU-
	Bifora americana	1	NI
	Centaurea americana	1	NI
	Plantago patagonica	+	FACU-
USACE - SP10Q4	*Schizachyrium scoparium*	5	FACU-
	Hedyotis nigricans	2	NI
	Symphyotrichum ericoides	2	FACU-
	Plantago patagonica	1	FACU-
USACE - SP10Q5	*Schizachyrium scoparium*	5	FACU-
	Gaillardia pulchella	3	NI
	Ambrosia trifida	2	FAC
	Symphyotrichum ericoides	+	FACU-
	Bifora americana	+	NI
USACE - SP10Q6	*Hedyotis nigricans*	4	NI
	Symphyotrichum ericoides	4	FACU-
	Cirsium undulatum	2	FACU
	Monarda citriodora	+	NI
USACE - SP11Q1	*Hedyotis nigricans*	4	NI
	Monarda citriodora	3	NI
	Symphyotrichum ericoides	3	FACU-
	Bifora americana	2	NI
	Muhlenbergia reverchonii	2	FAC
	Ambrosia trifida	+	FAC
USACE - SP11Q2	*Hedyotis nigricans*	3	NI
	Symphyotrichum ericoides	3	FACU-
	Bromus arvensis	1	NI
	Bifora americana	+	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP11Q3	*Symphyotrichum ericoides*	3	FACU-
	Mimosa roemeriana	2	NI
	Hedyotis nigricans	2	NI
	Bromus arvensis	1	NI
USACE - SP11Q4	*Hedyotis nigricans*	4	NI
	Macrophytic crust	2	
	Linum rigidum var. *rigidum*	1	NI
	Plantago wrightiana	1	NI
	Schizachyrium scoparium	1	FACU-
	Symphyotrichum ericoides	1	FACU-
USACE - SP11Q5	*Symphyotrichum ericoides*	4	FACU-
	Erygium leavenworthii	2	NI
	Hedyotis nigricans	2	NI
	Plantago wrightiana	1	NI
	Mimosa roemeriana	1	NI
	Bifora americana	+	NI
	Plantago patagonica	r	FACU-
USACE - SP11Q6	*Andropogon gerardii*	4	FACU
	Ceanothus americanus	2	NI
	Bromus arvensis	1	NI
	Hedyotis nigricans	1	NI
	Symphyotrichum ericoides	1	FACU-
	Plantago wrightiana	+	NI
	Salvia texana	r	NI
USACE - SP11Q7	*Hedeoma reverchonii* var. *reverchonii*	3	NI
	Hedyotis nigricans	3	NI
	Salvia texana	3	NI
	Symphyotrichum ericoides	3	FACU-
	Centaurea americana	+	NI
	Plantago patagonica	+	FACU-
	Plantago wrightiana	+	NI
	Rosa foliolosa	+	NI
USACE - SP11Q8	*Hedyotis nigricans*	4	NI
	Ceanothus americanus	3	NI
	Sporobolus compositus var. *drummondii*	2	NI
	Salvia texana	1	NI
	Muhlenbergia reverchonii	1	FAC
	Hedeoma reverchonii var. *reverchonii*	+	NI
USACE - SP11Q9	*Sporobolus compositus* var. *drummondii*	3	NI
	Hedyotis nigricans	2	NI
	Gaillardia pulchella	1	NI
	Hedeoma reverchonii var. *reverchonii*	1	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP11Q9	*Plantago wrightiana*	1	NI
	Salvia texana	1	NI
	Symphyotrichum ericoides	r	FACU-
USACE - SP11Q10	*Muhlenbergia reverchonii*	5	FAC
	Hedyotis nigricans	2	NI
	Symphyotrichum ericoides	2	FACU-
	Stillingia texana	1	NI
	Bifora americana	+	NI
	Gaura suffulta	+	NI
	Lythrum californicum	+	OBL
	Rosa foliolosa	+	NI
USACE - SP11Q11	*Gaillardia pulchella*	5	NI
	Hedyotis nigricans	4	NI
	Muhlenbergia reverchonii	3	FAC
	Rosa foliolosa	2	NI
	Salvia texana	1	NI
	Bromus arvensis	r	NI
	Dichanthelium acuminatum var. *lindheimeri*	r	FAC
	Helianthus annuus	r	FAC
USACE - SP11Q12	*Sporobolus compositus* var. *drummondii*	5	NI
	Hedeoma reverchonii var. *reverchonii*	4	NI
	Muhlenbergia reverchonii	4	FAC
	Plantago wrightiana	+	NI
USACE - SP11Q13	*Hedeoma reverchonii* var. *reverchonii*	3	NI
	Plantago wrightiana	3	NI
	Andropogon gerardii	3	FACU
	Rosa foliolosa	+	NI
	Amsonia ciliata var. *texana*	+	NI
USACE - SP11Q14	*Schizachyrium scoparium*	4	FACU+
	Rosa foliolosa	3	NI
	Hedyotis nigricans	2	NI
	Amsonia ciliata var. *texana*	1	NI
	Bromus arvensis	1	NI
	Gaura suffulta	1	NI
	Plantago wrightiana	r	NI
USACE - SP12Q1	*Schizachyrium scoparium*	5	FACU-
	Symphyotrichum ericoides	4	FACU-
	Bifora americana	2	NI
	Bromus arvensis	2	NI
USACE - SP12Q2	*Schizachyrium scoparium*	4	FACU-
	Teucrium canadense	4	FACW-

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP12Q2	*Symphyotrichum ericoides*	3	FACU-
	Monarda citriodora	2	NI
	Rosa foliolosa	2	NI
	Bromus arvensis	1	NI
	Salvia texana	+	NI
USACE - SP12Q3	*Gaillardia pulchella*	4	NI
	Hedyotis nigricans	3	NI
	Monarda citriodora	2	NI
	Symphyotrichum ericoides	2	FACU-
	Centaurea americana	1	NI
	Ambrosia trifida	+	FAC
USACE - SP12Q4	*Schizachyrium scoparium*	3	FACU-
	Symphyotrichum ericoides	3	FACU-
	Teucrium canadense	3	FACW-
	Ambrosia trifida	2	FAC
	Monarda citriodora	+	NI
USACE - SP12Q5	*Schizachyrium scoparium*	5	FACU-
	Teucrium canadense	3	FACW-
	Symphyotrichum ericoides	1	FACU-
	Centaurea americana	r	NI
USACE - SP13Q1	*Ambrosia trifida*	3	FAC
	Schizachyrium scoparium	3	FACU-
	Symphyotrichum ericoides	3	FACU-
	Bromus arvensis	1	NI
	Rosa foliolosa	+	NI
	Monarda citriodora	r	NI
USACE - SP13Q2	*Schizachyrium scoparium*	4	FACU-
	Ambrosia trifida	3	FAC
	Bromus arvensis	2	NI
	Monarda citriodora	1	NI
	Rosa foliolosa	+	NI
USACE - SP13Q3	*Rosa foliolosa*	3	NI
	Teucrium canadense	3	FACW-
	Ambrosia trifida	2	FAC
	Bromus arvensis	2	NI
	Bifora americana	1	NI
USACE - SP13Q4	*Centaurea americana*	4	NI
	Schizachyrium scoparium	3	FACU-
	Bromus arvensis	2	NI
USACE - SP13Q5	*Rosa foliolosa*	3	NI
	Schizachyrium scoparium	3	FACU-
	Teucrium canadense	3	FACW-

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP13Q5	*Bromus arvensis*	1	NI
	Monarda citriodora	+	NI
USACE - SP13Q6	*Teucrium canadense*	4	FACW-
	Bromus arvensis	2	NI
	Rosa foliolosa	2	NI
	Bifora americana	+	NI
USACE - SP14Q1	*Dracopis amplexicaulis*	2	FAC+
	Ambrosia trifida	4	FAC
	Symphyotrichum ericoides	2	FACU-
	Bromus arvensis	2	NI
	Bifora americana	+	NI
USACE - SP14Q2	*Allium runyonii*	3	NI
	Dracopis amplexicaulis	1	FAC+
	Ambrosia trifida	4	FAC
	Bromus arvensis	1	NI
	Eleocharis montevidensis	2	FACW+
USACE - SP14Q3	*Ambrosia trifida*	5	FAC
	Bromus arvensis	1	NI
	Dracopis amplexicaulis	3	FAC+
	Bifora americana	3	NI
USACE - SP14Q4	*Symphyotrichum ericoides*	4	FACU-
	Dracopis amplexicaulis	2	FAC+
	Bromus arvensis	2	NI
	Bifora americana	+	NI
USACE - SP14Q5	*Dracopis amplexicaulis*	5	FAC+
	Symphyotrichum ericoides	2	FACU-
	Tephrosia virginiana	r	NI
	Ambrosia trifida	1	FAC
	Bromus arvensis	2	NI
USACE - SP14Q6	*Symphyotrichum ericoides*	3	FACU-
	Bromus arvensis	3	NI
	Dracopis amplexicaulis	3	FAC+
	Ambrosia trifida	2	FAC
	Carex microdonta	1	OBL
	Bifora americana	1	NI
USACE - SP15Q1	*Andropogon gerardii*	6	FACU
	Bromus arvensis	2	NI
	Helianthus maximiliani	+	FACU-
USACE - SP15Q2	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC
	Symphyotrichum ericoides	+	FACU-
USACE - SP15Q3	*Andropogon gerardii*	6	FACU

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP15Q3	*Ambrosia trifida*	1	FAC
	Bromus arvensis	1	NI
USACE - SP16Q1	*Mimosa roemeriana*	4	NI
	Dracopis amplexicaulis	2	FAC+
	Bromus arvensis	2	NI
USACE - SP16Q2	*Bromus arvensis*	4	NI
	Helianthus maximiliani	4	FACU-
	Bifora americana	2	NI
	Monarda citriodora	+	NI
	Dracopis amplexicaulis	1	FAC+
	Teucrium canadense	+	FACW-
USACE - SP16Q3	*Bromus arvensis*	4	NI
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	+	OBL
	Monarda citriodora	+	NI
	Bifora americana	1	NI
USACE - SP16Q4	*Symphyotrichum ericoides*	5	FACU-
	Ambrosia trifida	2	FAC
	Bifora americana	1	NI
	Carex microdonta	+	OBL
	Monarda citriodora	+	NI
USACE - SP16Q5	*Bromus arvensis*	3	NI
	Andropogon gerardii	2	FACU
	Teucrium canadense	1	FACW-
	Bifora americana	+	NI
	Monarda citriodora	+	NI
	Symphyotrichum ericoides	+	FACU-
USACE - SP16Q6	*Ambrosia trifida*	4	FAC
	Rosa foliolosa	2	NI
	Opuntia phaeacantha	2	NI
	Bromus arvensis	1	NI
	Andropogon gerardii	1	FACU
	Monarda citriodora	+	NI
USACE - SP16Q7	*Ambrosia trifida*	4	FAC
	Andropogon gerardii	3	FACU
	Bromus arvensis	+	NI
USACE - SP16Q8	*Andropogon gerardii*	4	FACU
	Ambrosia trifida	3	FAC
	Bromus arvensis	1	NI
	Symphyotrichum ericoides	1	FACU-
	Monarda citriodora	+	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP17Q1	*Ambrosia trifida*	4	FAC
	Schizachyrium scoparium	3	FACU-
	Elymus canadensis	2	FAC+
	Symphyotrichum ericoides	2	FACU-
	Hedyotis nigricans	+	NI
	Bromus arvensis	+	NI
	Monarda citriodora	r	NI
USACE - SP17Q2	*Symphyotrichum ericoides*	4	FACU-
	Ambrosia trifida	2	FAC
	Elymus canadensis	2	FAC+
	Schizachyrium scoparium	2	FACU-
	Hedyotis nigricans	1	NI
USACE - SP17Q3	*Andropogon gerardii*	5	FACU
	Elymus canadensis	2	FAC+
	Symphyotrichum ericoides	2	FACU-
USACE - SP18Q1	*Symphyotrichum ericoides*	6	FACU-
	Ambrosia trifida	3	FAC
	Allium runyonii	+	NI
	Carex microdonta	+	OBL
	Dichanthelium acuminatum var. *lindheimeri*	+	FAC
	Dracopis amplexicaulis	+	FAC+
USACE - SP18Q2	*Eleocharis montevidensis*	3	FACW+
	Symphyotrichum ericoides	3	FACU-
	Juncus texanus	2	OBL
	Neptunia lutea	1	FACU
	Dracopsis amplexicaulis	+	FAC+
USACE - SP18Q3	*Eleocharis montevidensis*	5	FACW+
	Bromus arvensis	4	NI
	Ambrosia trifida	2	FAC
	Lythrum californicum	2	OBL
	Allium runyonii	r	NI
	Dracopis amplexicaulis	r	FAC+
USACE - SP18Q4	*Eleocharis montevidensis*	5	FACW+
	Carex microdonta	2	OBL
	Symphyotrichum ericoides	2	FACU-
	Bromus arvensis	+	NI
	Allium runyonii	r	NI
	Dichanthelium acuminatum var. *lindheimeri*	r	FAC
USACE - SP18Q5	*Eleocharis montevidensis*	5	FACW+
	Symphyotrichum ericoides	2	FACU-
	Allium runyonii	+	NI

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - SP18Q5	*Bromus arvensis*	+	NI
	Juncus texanus	+	OBL
	Dracopis amplexicaulis	r	FAC+
USACE - SP19Q1	*Andropogon gerardii*	5	FACU
	Helianthus maximiliani	4	FACU-
USACE - SP19Q2	*Andropogon gerardii*	6	FACU
	Bromus arvensis	1	NI
USACE - SP19Q3	*Schizachyrium scoparium*	6	FACU-
	Bromus arvensis	3	NI
	Symphyotrichum ericoides	1	FACU-
	Ambrosia trifida	+	FAC
USACE - SP20Q1	*Ambrosia trifida*	1	FAC
	Centaurea americana	1	NI
	Teucrium canadense	1	FACW-
USACE - SP20Q2	*Gaillardia pulchella*	4	NI
	Helianthus annuus	2	FAC
	Bifora americana	1	NI
	Mimosa roemeriana	1	NI
	Bromus arvensis	+	NI
	Monarda citriodora	+	NI
	Plantago patagonica	+	FACU-
	Ambrosia trifida	r	FAC
USACE - SP20Q3	*Gaillardia pulchella*	5	NI
	Andropogon gerardii	2	FACU
	Symphyotrichum ericoides	2	FACU-
	Bromus arvensis	1	NI
	Hedyotis nigricans	1	NI
	Lythrum californicum	r	OBL
USACE - SP20Q4	*Andropogon gerardii*	4	FACU
	Salvia texana	4	NI
	Hedeoma reverchonii var. *reverchonii*	1	NI
USACE - SP20Q5	*Andropogon gerardii*	5	FACU
	Gaillardia pulchella	3	NI
	Centaurea americana	+	NI
	Plantago patagonica	+	FACU-
	Bromus arvensis	r	NI
USACE - SP20Q6	*Andropogon gerardii*	4	FACU
	Gaillardia pulchella	3	NI
	Hedeoma reverchonii var. *reverchonii*	3	NI
	Ambrosia trifida	+	FAC
USACE - SP20Q7	*Andropogon gerardii*	6	FACU
	Carex microdonta	3	OBL

Spring Quadrat Data: Continuation of Table 1			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
	Bromus arvensis	2	NI
	Ambrosia trifida	+	FAC
USACE - SP20Q8	*Bromus arvensis*	3	NI
	Carex microdonta	3	OBL
	Muhlenbergia reverchonii	3	FAC
	Ambrosia trifida	2	FAC
	Teucrium canadense	2	FACW-
	Monarda citriodora	+	NI

Table 2: Quadrat data for fall sampling period.

Fall Quadrat Data			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP1Q1	*Muhlenbergia reverchonii*	6	FAC
	Sorghastrum nutans	1	FACU
	Symphyotrichum ericoides	1	FACU-
	Cirsium undulatum	+	FACU
USACE - FP1Q2	*Schizachyrium scoparium*	4	FACU+
	Sorghastrum nutans	3	FACU
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	1	OBL
	Cirsium undulatum	1	FACU
	Centaurea americana	+	NI
USACE - FP1Q3	Debris	5	
	Ambrosia trifida	3	FAC
	Symphyotrichum ericoides	3	FACU-
	Muhlenbergia reverchonii	1	FAC
	Tridens muticus	1	FACW
USACE - FP1Q4	*Symphyotrichum ericoides*	5	FACU-
	Croton monanthogynus	3	NI
	Carex microdonta	2	OBL
	Cirsium undulatum	2	FACU
	Schizachyrium scoparium	2	FACU+
	Centaurea americana	1	NI
USACE - FP1Q5	*Symphyotrichum ericoides*	5	FACU-
	Schizachyrium scoparium	5	FACU+
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Carex microdonta	2	OBL
USACE - FP1Q6	*Bouteloua hirsuta* var. *hirsuta*	5	NI
	Symphyotrichum ericoides	3	FACU-
	Ambrosia trifida	1	FAC
	Carex microdonta	1	OBL

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP1Q6	*Schizachyrium scoparium*	1	FACU+
	Tridens muticus	1	FACW
USACE - FP1Q7	*Croton monanthogynus*	4	NI
	Muhlenbergia reverchonii	4	FAC
	Ambrosia trifida	3	FAC
	Schizachyrium scoparium	3	FACU+
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	2	OBL
	Cirsium undulatum	2	FACU
	Hedyotis nigricans	2	NI
USACE - FP1Q8	Bare ground	3	
	Symphyotrichum ericoides	5	FACU-
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Carex microdonta	2	OBL
	Schizachyrium scoparium	2	FACU+
	Cirsium undulatum	1	FACU
	Hedeoma reverchonii var. *reverchonii*	1	NI
USACE - FP1Q9	*Carex microdonta*	4	OBL
	Muhlenbergia reverchonii	4	FAC
	Smilax bona-nox	4	FAC
	Cirsium undulatum	3	FACU
	Croton monanthogynus	3	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP1Q10	*Bouteloua hirsuta* var. *hirsuta*	5	NI
	Carex microdonta	3	OBL
	Muhlenbergia reverchonii	3	FAC
	Cirsium undulatum	2	FACU
	Muhlenbergia reverchonii	5	FAC
	Bouteloua hirsuta var. *hirsuta*	4	NI
	Cirsium undulatum	3	FACU
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	1	OBL
	Schizachyrium scoparium	1	FACU+
USACE - FP2Q1	*Muhlenbergia reverchonii*	6	FAC
	Bouteloua hirsuta var. *hirsuta*	3	NI
	Cirsium undulatum	2	FACU
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	1	OBL
	Schizachyrium scoparium	1	FACU+
USACE - FP2Q2	*Muhlenbergia reverchonii*	6	FAC
	Carex microdonta	2	OBL
	Cirsium undulatum	2	FACU
	Schizachyrium scoparium	2	FACU+
	Symphyotrichum ericoides	2	FACU-
	Bouteloua hirsuta var. *hirsuta*	1	NI

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP2Q3	*Bouteloua hirsuta* var. *hirsuta*	6	NI
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	1	OBL
	Muhlenbergia reverchonii	1	FAC
	Schizachyrium scoparium	1	FACU+
USACE - FP2Q4	*Hedyotis nigricans*	5	NI
	Muhlenbergia reverchonii	4	FAC
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Cirsium undulatum	1	FACU
	Schizachyrium scoparium	1	FACU+
USACE - FP2Q5	*Muhlenbergia reverchonii*	6	FAC
	Hedyotis nigricans	2	NI
	Smilax bona-nox	2	FAC
	Symphyotrichum ericoides	+	FACU-
USACE - FP2Q6	*Bouteloua hirsuta* var. *hirsuta*	4	NI
	Muhlenbergia reverchonii	4	FAC
	Symphyotrichum ericoides	4	FACU-
	Schizachyrium scoparium	+	FACU+
	Spiranthes ovalis	r	FAC
USACE - FP2Q7	*Muhlenbergia reverchonii*	5	FAC
	Symphyotrichum ericoides	3	FACU-
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Smilax bona-nox	1	FAC
USACE - FP2Q8	*Dichanthelium acuminatum* var. *lindheimeri*	4	FAC
	Bare ground	3	
	Symphyotrichum ericoides	2	FACU-
	Bouteloua hirsuta var. *hirsuta*	1	NI
USACE - FP2Q9	*Muhlenbergia reverchonii*	5	FAC
	Debris	3	
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	1	OBL
USACE - FP3Q1	*Muhlenbergia reverchonii*	6	FAC
	Schizachyrium scoparium	2	FACU+
	Bouteloua hirsuta subsp. hirsuta	1	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Symphyotrichum ericoides	1	FACU-
USACE - FP3Q2	*Bouteloua hirsuta subsp. hirsuta*	3	NI
	Debris	3	
	Carex microdonta	2	OBL
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Symphyotrichum ericoides	1	FACU-
USACE - FP3Q3	*Symphyotrichum ericoides*	5	FACU-
	Muhlenbergia reverchonii	4	FAC
	Carex microdonta	3	OBL
	Debris	1	

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP3Q3	*Dichanthelium acuminatum* var. *lindheimeri*	1	FAC
USACE - FP3Q4	*Muhlenbergia reverchonii*	5	FAC
	Symphyotrichum ericoides	4	FACU-
	Carex microdonta	3	OBL
USACE - FP3Q5	*Muhlenbergia reverchonii*	6	FAC
	Hedyotis nigricans	2	NI
	Symphyotrichum ericoides	2	FACU-
	Iva angustifolia	1	NI
USACE - FP3Q6	*Muhlenbergia reverchonii*	6	FAC
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	1	OBL
USACE - FP4Q1	*Muhlenbergia reverchonii*	6	FAC
	Symphyotrichum ericoides	3	FACU-
USACE - FP4Q2	Debris	4	
	Ambrosia trifida	4	FAC
	Bare ground	4	
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	3	OBL
USACE - FP4Q3	*Tridens muticus*	5	FACW
	Carex microdonta	2	OBL
	Iva angustifolia	1	NI
USACE - FP4Q4	*Ambrosia trifida*	5	FAC
	Carex microdonta	3	OBL
	Muhlenbergia reverchonii	3	FAC
	Symphyotrichum ericoides	3	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	+	FAC
USACE - FP5Q1	*Ambrosia trifida*	6	FAC
	Carex microdonta	2	OBL
	Debris	2	
USACE - FP5Q2	Debris	5	
	Symphyotrichum ericoides	5	FACU-
USACE - FP5Q3	*Ambrosia trifida*	5	FAC
	Symphyotrichum ericoides	5	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	3	FAC
	Hedyotis nigricans	3	NI
USACE - FP5Q4	*Ambrosia trifida*	5	FAC
	Debris	3	
	Carex microdonta	2	OBL
USACE - FP5Q5	*Muhlenbergia reverchonii*	6	FAC
	Bouteloua hirsuta var. *hirsuta*	3	NI
	Carex microdonta	3	OBL
	Ambrosia trifida	1	FAC
	Cirsium undulatum	1	FACU
	Schizachyrium scoparium	1	FACU+

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP5Q6	*Symphyotrichum ericoides*	6	FACU-
	Muhlenbergia reverchonii	5	FAC
	Schizachyrium scoparium	2	FACU+
	Tridens muticus	2	FACW
USACE - FP5Q7	*Symphyotrichum ericoides*	6	FACU-
	Muhlenbergia reverchonii	4	FAC
	Carex microdonta	3	OBL
USACE - FP6Q1	*Symphyotrichum ericoides*	6	FACU-
	Iva angustifolia	4	NI
	Tridens muticus	4	FACW
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP6Q2	*Symphyotrichum ericoides*	6	FACU-
	Iva angustifolia	4	NI
	Carex microdonta	2	OBL
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
USACE - FP6Q3	*Bouteloua hirsuta* var. *hirsuta*	5	NI
	Symphyotrichum ericoides	5	FACU-
	Tridens muticus	2	FACW
	Carex microdonta	1	OBL
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP6Q4	*Symphyotrichum ericoides*	6	FACU-
	Tridens muticus	5	FACW
	Carex microdonta	2	OBL
USACE - FP7Q1	Debris	5	
	Symphyotrichum ericoides	4	FACU-
	Tridens muticus	4	FACW
	Carex microdonta	2	OBL
USACE - FP7Q2	*Dichanthelium acuminatum* var. *lindheimeri*	6	FAC
	Carex microdonta	3	OBL
	Iva angustifolia	+	NI
USACE - FP7Q3	Debris	5	
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Muhlenbergia reverchonii	2	FAC
	Symphyotrichum ericoides	2	FACU-
	Carex microdonta	2	OBL
USACE - FP7Q4	*Tridens muticus*	6	FACW
	Symphyotrichum ericoides	+	FACU-
USACE - FP8Q1	*Symphyotrichum ericoides*	5	FACU-
	Lippia nodiflora	2	FACW
	Tridens muticus	2	FACW
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP8Q2	*Symphyotrichum ericoides*	4	FACU-
	Lippia nodiflora	3	FACW
	Debris	3	
	Tridens muticus	2	FACW

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP8Q2	*Ambrosia trifida*	1	FAC
	Carex microdonta	1	OBL
USACE - FP8Q3	*Lippia nodiflora*	5	FACW
	Symphyotrichum ericoides	3	FACU-
	Tridens muticus	3	FACW
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Iva angustifolia	1	NI
	Carex microdonta	+	OBL
	Dichanthelium oligosanthes var. *scribnerianum*	r	FACU
USACE - FP8Q4	*Dichanthelium acuminatum* var. *lindheimeri*	5	FAC
	Symphyotrichum ericoides	5	FACU-
	Carex microdonta	3	OBL
	Debris	3	
	Iva angustifolia	2	NI
USACE - FP8Q5	*Symphyotrichum ericoides*	5	FACU-
	Carex microdonta	3	OBL
	Andropogon gerardii	2	FACU
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Schizachyrium scoparium	+	FACU+
USACE - FP8Q6	*Symphyotrichum ericoides*	3	FACU-
	Unknown rosette annuals	3	
	Carex microdonta	2	OBL
	Tridens muticus	1	FACW
	Bothriochloa laguroides	+	NI
USACE - FP8Q7	*Symphyotrichum ericoides*	5	FACU-
	Lippia nodiflora	3	FACW
	Iva angustifolia	2	NI
	Schizachyrium scoparium	2	FACU+
USACE - FP8Q8	*Schizachyrium scoparium*	4	FACU+
	Tridens muticus	4	FACW
	Carex microdonta	3	OBL
	Lippia nodiflora	3	FACW
	Muhlenbergia reverchonii	3	FAC
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
USACE - FP8Q9	*Lippia nodiflora*	6	FACW
	Carex microdonta	3	OBL
	Dichanthelium acuminatum var. *lindheimeri*	3	FAC
	Schizachyrium scoparium	3	FACU+
	Symphyotrichum ericoides	3	FACU-
USACE - FP9Q1	*Andropogon gerardii*	4	NI
	Carex microdonta	4	OBL
	Muhlenbergia reverchonii	4	FAC
	Dichanthelium acuminatum var. *lindheimeri*	3	FAC

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP9Q1	*Iva angustifolia*	2	NI
	Symphyotrichum ericoides	2	FACU-
USACE - FP9Q2	Debris	4	
	Dichanthelium acuminatum var. *lindheimeri*	4	FAC
	Carex microdonta	3	OBL
USACE - FP9Q3	*Bouteloua hirsuta subsp. hirsuta*	4	NI
	Tridens muticus	2	FACW
	Carex microdonta	1	OBL
USACE - FP9Q4	*Tridens muticus*	5	FACW
	Debris	4	FACW
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	3	OBL
USACE - FP9Q5	*Tridens muticus*	5	FACW
	Schizachyrium scoparium	5	FACU+
	Carex microdonta	3	OBL
	Symphyotrichum ericoides	2	FACU-
USACE - FP9Q6	*Schizachyrium scoparium*	4	FACU+
	Tridens muticus	4	FACW
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	2	OBL
	Iva angustifolia	2	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP9Q7	Debris	4	
	Carex microdonta	4	OBL
	Symphyotrichum ericoides	4	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	3	FAC
	Muhlenbergia reverchonii	1	FAC
USACE - FP9Q8	*Tridens muticus*	5	FACW
	Dichanthelium acuminatum var. *lindheimeri*	5	FAC
USACE - FP10Q1	*Iva angustifolia*	5	NI
	Tridens muticus	4	FACW
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	2	OBL
USACE - FP10Q2	*Iva angustifolia*	5	NI
	Symphyotrichum ericoides	3	FACU-
	Carex microdonta	2	OBL
USACE - FP10Q3	*Ambrosia trifida*	6	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP10Q4	*Iva angustifolia*	6	NI
	Carex microdonta	4	OBL
	Lippia nodiflora	1	FACW
USACE - FP10Q5	*Ambrosia trifida*	6	FAC
	Lippia nodiflora	1	FACW

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP10Q6	*Ambrosia trifida*	5	FAC
	Symphyotrichum ericoides	4	FACU-
	Tridens muticus	4	FACW
USACE - FP10Q7	*Ambrosia trifida*	4	FAC
	Carex microdonta	4	OBL
	Iva angustifolia	4	NI
	Symphyotrichum ericoides	4	FACU-
USACE - FP11Q1	*Ambrosia trifida*	5	FAC
	Iva angustifolia	3	NI
	Carex microdonta	2	OBL
USACE - FP11Q2	Debris	5	
	Ambrosia trifida	2	FAC
	Gutierrezia texana	1	NI
USACE - FP11Q3	*Schizachyrium scoparium*	5	FACU+
	Croton monanthogynus	3	NI
	Carex microdonta	2	OBL
USACE - FP11Q4	*Ambrosia trifida*	6	FAC
	Andropogon gerardii	1	FACU
	Schizachyrium scoparium	1	FACU+
	Symphyotrichum ericoides	+	FACU-
USACE - FP11Q5	*Ambrosia trifida*	5	FAC
	Tridens muticus	4	FACW*
	Carex microdonta	3	OBL
	Symphyotrichum ericoides	3	FACU-
USACE - FP11Q6	*Ambrosia trifida*	6	FAC
	Carex microdonta	2	OBL
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP11Q7	*Ambrosia trifida*	5	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP11Q8	*Muhlenbergia reverchonii*	4	FAC
	Iva angustifolia	3	NI
	Gutierrezia texana	3	NI
USACE - FP11Q9	*Symphyotrichum ericoides*	5	FACU-
	Debris	3	
USACE - FP12Q1	*Schizachyrium scoparium*	5	FACU-
	Gutierrezia texana	3	NI
USACE - FP12Q2	*Schizachyrium scoparium*	4	FACU-
	Sorghastrum nutans	3	FACU
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Gutierrezia texana	2	NI
USACE - FP12Q3	*Schizachyrium scoparium*	5	FACU-
	Sorghastrum nutans	3	FACU
	Hedeoma reverchonii var. *reverchonii*	1	NI

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP12Q4	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	2	FAC
USACE - FP12Q5	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	3	FAC
USACE - FP13Q1	*Schizachyrium scoparium*	5	FACU-
	Hedyotis nigricans	3	NI
USACE - FP13Q2	*Schizachyrium scoparium*	5	FACU-
	Hedyotis nigricans	2	NI
USACE - FP13Q3	*Schizachyrium scoparium*	4	FACU-
	Muhlenbergia reverchonii	1	FAC
USACE - FP13Q4	*Schizachyrium scoparium*	5	FACU-
	Sorghastrum nutans	5	FACU
USACE - FP13Q5	*Sorghastrum nutans*	5	FACU
	Tridens muticus	3	FACW*
	Hedyotis nigricans	2	NI
USACE - FP13Q6	*Schizachyrium scoparium*	4	FACU-
	Sorghastrum nutans	3	FACU
	Ambrosia trifida	3	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP13Q7	*Schizachyrium scoparium*	6	FACU-
	Gutierrezia texana	+	NI
	Hedeoma reverchonii var. *reverchonii*	+	NI
	Hedyotis nigricans	+	NI
USACE - FP13Q8	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	4	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP13Q9	*Schizachyrium scoparium*	5	FACU-
	Bouteloua hirsuta var. *hirsuta*	3	NI
USACE - FP13Q10	*Symphyotrichum ericoides*	2	FACU-
	Hedyotis nigricans	2	NI
	Schizachyrium scoparium	5	FACU-
USACE - FP13Q11	*Schizachyrium scoparium*	5	FACU-
	Ambrosia trifida	2	FAC
	Hedyotis nigricans	1	NI
USACE - FP14Q1	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC
	Symphyotrichum ericoides	2	FACU-
USACE - FP14Q2	*Andropogon gerardii*	6	FACU
	Schizachyrium scoparium	2	FACU-
	Ambrosia trifida	2	FAC
USACE - FP14Q3	Bare ground	4	
	Ambrosia trifida	3	FAC
USACE - FP14Q4	*Ambrosia trifida*	4	FAC
	Bare ground	4	
USACE - FP15Q1	*Ambrosia trifida*	4	FAC

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP15Q1	*Tridens muticus*	3	FACW*
	Symphyotrichum ericoides	3	FACU-
USACE - FP15Q2	*Muhlenbergia reverchonii*	4	FAC
	Ambrosia trifida	4	FAC
	Symphyotrichum ericoides	3	FACU-
USACE - FP15Q3	*Symphyotrichum ericoides*	5	FACU-
	Ambrosia trifida	3	FAC
	Iva angustifolia	2	NI
USACE - FP15Q4	*Muhlenbergia reverchonii*	5	FAC
	Symphyotrichum ericoides	4	FACU-
	Tridens muticus	2	FACW*
USACE - FP16Q1	*Tridens muticus*	5	FACW*
	Ambrosia trifida	3	FAC
USACE - FP16Q2	*Muhlenbergia reverchonii*	4	FAC
	Rosa foliolosa	3	NI
	Tridens muticus	3	FACW*
USACE - FP16Q3	*Tridens muticus*	4	FACW*
	Muhlenbergia reverchonii	3	FAC
	Rosa foliolosa	2	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP16Q4	*Tridens muticus*	5	FACW*
	Liatris glandulosa	1	NI
USACE - FP16Q5	*Liatris glandulosa*	4	NI
	Muhlenbergia reverchonii	4	FAC
USACE - FP16Q6	*Tridens muticus*	6	FACW*
	Bare ground	1	
USACE - FP16Q7	*Gutierrezia texana*	4	NI
	Tridens muticus	4	FACW*
	Symphyotrichum ericoides	2	FACU-
USACE - FP16Q8	*Tridens muticus*	5	FACW*
	Muhlenbergia reverchonii	3	FAC
	Rosa foliolosa	+	NI
	Symphyotrichum ericoides	+	FACU-
USACE - FP16Q9	*Tridens muticus*	4	FACW*
	Bouteloua hirsuta var. *hirsuta*	3	NI
USACE - FP16Q10	*Tridens muticus*	5	FACW*
	Symphyotrichum ericoides	2	FACU-
	Liatris glandulosa	1	NI
USACE - FP16Q11	*Tridens muticus*	4	FACW*
	Symphyotrichum ericoides	3	FACU-
	Gutierrezia texana	2	NI
USACE - FP16Q12	*Symphyotrichum ericoides*	4	FACU-
	Muhlenbergia reverchonii	3	FAC
	Unknown rosette annuals	2	
	Gutierrezia texana	1	NI

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP16Q13	*Symphyotrichum ericoides*	5	FACU-
	Muhlenbergia reverchonii	4	FAC
USACE - FP16Q14	*Tridens muticus*	6	FACW*
	Liatris glandulosa	2	NI
USACE - FP16Q15	*Tridens muticus*	5	FAC
	Debris	2	
USACE - FP17Q1	*Schizachyrium scoparium*	4	FACU+
	Symphyotrichum ericoides	4	FACU-
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP17Q2	*Schizachyrium scoparium*	5	FACU+
	Symphyotrichum ericoides	3	FACU-
	Bouteloua hirsuta var. *hirsuta*	2	NI
	Asclepias asperula	+	
USACE - FP17Q3	*Schizachyrium scoparium*	6	FACU+
	Rosa foliolosa	2	NI
USACE - FP17Q4	*Symphyotrichum ericoides*	5	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	3	FAC
USACE - FP17Q5	Debris	3	
	Elymus canadensis	3	FAC+
	Schizachyrium scoparium	3	FACU+
	Symphyotrichum ericoides	3	FACU-
USACE - FP17Q6	*Ambrosia trifida*	4	FAC
	Andropogon gerardii	4	FACU
	Cirsium undulatum	3	FACU
USACE - FP17Q7	*Elymus canadensis*	4	FAC+
	Andropogon gerardii	4	FACU
	Schizachyrium scoparium	4	FACU+
	Rosa foliolosa	+	NI
USACE - FP17Q8	*Andropogon gerardii*	5	FACU
	Ambrosia trifida	1	FACU
USACE - FP18Q1	*Schizachyrium scoparium*	6	FACU+
	Rosa foliolosa	2	NI
	Gutierrezia texana	+	NI
USACE - FP18Q2	*Schizachyrium scoparium*	6	FACU+
	Rosa foliolosa	1	NI
USACE - FP18Q3	*Gutierrezia texana*	4	NI
	Rosa foliolosa	4	NI
	Croton monanthogynus	3	NI
	Bouteloua hirsuta var. *hirsuta*	1	NI
USACE - FP18Q4	*Schizachyrium scoparium*	5	FACU+
	Croton monanthogynus	4	NI
	Rosa foliolosa	3	NI
USACE - FP18Q5	*Teucrium canadense*	3	
	Symphyotrichum ericoides	5	FACU-

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP18Q5	Debris	+	
USACE - FP19Q1	*Eragrostis curtipedicellata*	5	NI
	Schizachyrium scoparium	3	FACU-
	Ambrosia trifida	2	FAC
	Gutierrezia texana	+	NI
USACE - FP19Q2	*Eragrostis curtipedicellata*	5	NI
	Ambrosia trifida	3	FAC
	Schizachyrium scoparium	3	FACU-
USACE - FP19Q3	*Eragrostis curtipedicellata*	6	NI
USACE - FP19Q4	*Eragrostis curtipedicellata*	5	NI
	Ambrosia trifida	3	FAC
USACE - FP20Q1	*Ambrosia trifida*	4	FAC
	Debris	3	
	Dichanthelium acuminatum var. *lindheimeri*	2	FAC
	Cirsium undulatum	2	FACU
	Teucrium canandense	1	FACW-
USACE - FP20Q2	*Bouteloua hirsuta subsp. hirsuta*	4	NI
	Teucrium canandense	3	FACW-
	Tridens muticus	2	FACW*
	Schizachyrium scoparium	1	FACU-
USACE - FP20Q3	*Andropogon gerardii*	4	FACU
	Schizachyrium scoparium	4	FACU-
	Symphyotrichum ericoides	3	FACU-
	Dichanthelium acuminatum var. *lindheimeri*	+	FAC
USACE - FP20Q4	*Schizachyrium scoparium*	5	FACU-
	Symphyotrichum ericoides	3	FACU-
	Rosa foliolosa	1	NI
USACE - FP20Q5	*Ambrosia trifida*	4	FAC
	Schizachyrium scoparium	4	FACU-
	Symphyotrichum ericoides	2	FACU-
USACE - FP20Q6	*Andropogon gerardii*	5	FACU
	Schizachyrium scoparium	3	FACU-
	Elymus canadensis	2	FAC+
USACE - FP20Q7	*Andropogon gerardii*	5	FACU
	Schizachyrium scoparium	4	FACU-
	Cirsium undulatum	2	FACU
USACE - FP20Q8	*Schizachyrium scoparium*	5	FACU-
	Andropogon gerardii	4	FACU
	Ambrosia trifida	+	FAC
USACE - FP20Q9	*Schizachyrium scoparium*	5	FACU-
	Andropogon gerardii	4	FACU
USACE - FP20Q10	*Ambrosia trifida*	5	FAC
	Bouteloua hirsuta var. *hirsuta*	4	NI
	Andropogon gerardii	3	FACU

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP21Q1	*Ambrosia trifida*	4	FAC
	Andropogon gerardii	4	FACU
	Rosa foliolosa	2	NI
USACE - FP21Q2	*Ambrosia trifida*	5	FAC
	Rosa foliolosa	3	NI
USACE - FP21Q3	*Ambrosia trifida*	6	FAC
	Schizachyrium scoparium	2	FACU-
	Rosa foliolosa	1	NI
	Cirsium undulatum	+	FACU
USACE - FP21Q4	*Ambrosia trifida*	6	FAC
	Schizachyrium scoparium	2	FACU-
	Teucrium canandense	1	FACW-
USACE - FP21Q5	Debris	4	
	Symphyotrichum ericoides	3	FACU-
	Ambrosia trifida	2	FAC
	Rosa foliolosa	2	NI
USACE - FP21Q6	*Andropogon gerardii*	4	FACU
	Ambrosia trifida	3	FAC
	Rosa foliolosa	2	NI
	Schizachyrium scoparium	1	FACU-
USACE - FP22Q1	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC
	Cirsium undulatum	+	FACU
USACE - FP22Q2	*Andropogon gerardii*	6	FACU
	Symphyotrichum ericoides	3	FACU-
USACE - FP22Q3	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	4	FAC
USACE - FP22Q4	*Andropogon gerardii*	4	FACU
	Teucrium canandense	4	FACW-
USACE - FP22Q5	*Andropogon gerardii*	3	FACU
	Teucrium canandense	3	FACW-
	Schizachyrium scoparium	3	FACU-
	Gutierrezia texana	1	NI
USACE - FP22Q6	*Andropogon gerardii*	5	FACU
	Croton monanthogynus	3	NI
	Schizachyrium scoparium	2	FACU-
	Gutierrezia texana	1	NI
USACE - FP22Q7	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	3	FAC
	Carex microdonta	2	OBL
USACE - FP22Q8	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC
USACE - FP22Q9	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP23Q1	*Andropogon gerardii*	4	FACU
	Ambrosia trifida	3	FAC
	Rosa foliolosa	2	NI
USACE - FP23Q2	*Andropogon gerardii*	5	FACU
	Rosa foliolosa	3	NI
	Schizachyrium scoparium	2	FACU-
	Symphyotrichum ericoides	1	FACU-
USACE - FP23Q3	*Andropogon gerardii*	4	FACU
	Gutierrezia texana	3	NI
	Rosa foliolosa	3	NI
	Ambrosia trifida	1	FAC
USACE - FP23Q4	*Andropogon gerardii*	5	FACU
	Rosa foliolosa	2	NI
	Symphyotrichum ericoides	1	FACU-
	Cirsium undulatum	+	FACU
USACE - FP23Q5	*Andropogon gerardii*	5	FACU
	Ambrosia trifida	3	FAC
	Rosa foliolosa	1	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP23Q6	*Andropogon gerardii*	6	FACU
	Ambrosia trifida	2	FAC
USACE - FP23Q7	*Andropogon gerardii*	6	FACU
	Rosa foliolosa	2	NI
	Symphyotrichum ericoides	+	FACU-
USACE - FP24Q1	*Teucrium canadense*	4	FACW-
	Rosa foliolosa	3	NI
	Symphyotrichum ericoides	2	FACU-
	Debris	2	
USACE - FP24Q2	*Hedeoma reverchonii* var. *reverchonii*	4	NI
	Teucrium canadense	4	FACW-
USACE - FP24Q3	*Teucrium canadense*	2	FACW-
	Symphyotrichum ericoides	1	FACU-
	Debris	5	
USACE - FP24Q4	*Teucrium canadense*	4	FACW-
	Debris	4	
	Rosa foliolosa	1	NI
	Symphyotrichum ericoides	+	FACU-
USACE - FP24Q5	*Andropogon gerardii*	5	FACU
	Rosa foliolosa	2	NI
	Symphyotrichum ericoides	2	FACU-
USACE - FP24Q6	*Symphyotrichum ericoides*	5	FACU-
	Teucrium canadense	3	FACW-
	Rosa foliolosa	2	NI
USACE - FP24Q7	*Hedeoma reverchonii* var. *reverchonii*	4	NI
	Teucrium canadense	4	FACW-

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP25Q1	*Symphyotrichum ericoides*	4	FACU-
	Eleocharis montevidensis	4	FACW+
	Carex microdonta	+	OBL
USACE - FP25Q2	*Eleocharis montevidensis*	3	FACW+
	Carex microdonta	3	OBL
	Debris	3	
	Gutierrezia texana	2	NI
USACE - FP25Q3	*Eleocharis montevidensis*	5	FACW+
	Debris	3	
	Carex microdonta	2	OBL
USACE - FP25Q4	*Eleocharis montevidensis*	5	FACW+
	Symphyotrichum ericoides	1	FACU-
USACE - FP25Q5	*Eleocharis montevidensis*	6	FACW+
	Symphyotrichum ericoides	1	FACU-
USACE - FP26Q1	*Andropogon gerardii*	5	FACU
	Ambrosia trifida	3	FAC
	Carex microdonta	1	OBL
	Rosa foliolosa	+	NI
USACE - FP26Q2	*Ambrosia trifida*	4	FAC
	Debris	3	
	Rosa foliolosa	+	NI
USACE - FP26Q3	*Ambrosia trifida*	4	FAC
	Debris	4	
	Andropogon gerardii	2	FACU
USACE - FP26Q4	*Andropogon gerardii*	5	FACU
	Ambrosia trifida	2	FAC
USACE - FP26Q5	*Schizachyrium scoparium*	6	FACU-
	Symphyotrichum ericoides	2	FACU-
USACE - FP26Q6	*Ambrosia trifida*	6	FAC
USACE - FP26Q7	*Ambrosia trifida*	4	FAC
	Andropogon gerardii	4	FACU
USACE - FP27Q1	*Dichanthelium acuminatum* var. *lindheimeri*	4	FAC
	Debris	4	
	Carex microdonta	3	OBL
	Sporobolus compositus var. *compositus*	1	NI
USACE - FP27Q2	*Symphyotrichum ericoides*	5	FACU-
	Carex microdonta	3	OBL
	Spiranthes cf. *ovalis*	r	FAC
USACE - FP27Q3	*Symphyotrichum ericoides*	3	FACU-
	Sporobolus compositus var. *compositus*	3	NI
	Carex microdonta	3	OBL
	Teucrium canadense	1	FACW-
	Cirsium undulatum	1	FACU
USACE - FP27Q4	Bare ground	5	
	Eleocharis montevidensis	2	FACW+

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP27Q4	*Sporobolus compositus* var. *compositus*	+	NI
	Ambrosia trifida	+	FAC
USACE - FP27Q5	*Eleocharis montevidensis*	4	FACW+
	Symphyotrichum ericoides	3	FACU-
	Ambrosia trifida	2	FAC
USACE - FP27Q6	*Ambrosia trifida*	3	FAC
	Muhlenbergia reverchonii	4	FAC
	Symphyotrichum ericoides	3	FACU-
	Eleocharis montevidensis	2	FACW+
USACE - FP27Q7	*Ambrosia trifida*	4	FAC
	Allium runyonii	3	NI
USACE - FP27Q8	*Symphyotrichum ericoides*	3	FACU-
	Ambrosia trifida	3	FAC
	Debris	3	
	Allium runyonii	+	NI
USACE - FP27Q9	*Symphyotrichum ericoides*	3	FACU-
	Ambrosia trifida	3	FAC
	Eleocharis montevidensis	3	FACW+
	Carex microdonta	1	OBL
USACE - FP28Q1	*Ambrosia trifida*	5	FAC
	Carex microdonta	1	FACU
	Sporobolus compositus var. *compositus*	+	OBL
USACE - FP28Q2	*Cirsium undulatum*	4	NI
	Croton monanthogynus	3	NI
	Hedeoma reverchonii var. *reverchonii*	2	FACW-
	Schizachyrium scoparium	2	FACW-
	Teucrium canadense	2	FACU-
USACE - FP28Q3	Debris	4	
	Croton monanthogynus	3	NI
	Teucrium canadense	3	FACW-
USACE - FP28Q4	*Schizachyrium scoparium*	5	FACU-
	Plantago wrightiana	2	NI
USACE - FP28Q5	*Croton monanthogynus*	4	NI
	Croton monanthogynus	2	NI
	Hedeoma reverchonii var. *reverchonii*	2	NI
USACE - FP28Q6	*Hedeoma reverchonii* var. *reverchonii*	4	NI
	Teucrium canadense	2	FACW-
	Schizachyrium scoparium	3	FACU-
	Ambrosia trifida	1	FAC
USACE - FP28Q7	*Symphyotrichum ericoides*	5	FACU-
	Croton monanthogynus	3	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
USACE - FP28Q8	*Croton monanthogynus*	4	NI
	Tridens muticus	4	FACW*
	Teucrium canadense	4	FACW-

Fall Quadrat Data: Continuation of Table 2			
Quadrat Name	**Species Name**	**Cover Class**	**Wetland Indicator Status**
USACE - FP28Q8	*Plantago wrightiana*	+	NI
USACE - FP28Q9	*Teucrium canadense*	3	FACW-
	Croton monanthogynus	3	NI
	Plantago wrightiana	+	NI
USACE - FP28Q10	*Croton monanthogynus*	4	NI
	Dichanthelium acuminatum var. *lindheimeri*	1	FAC
	Schizachyrium scoparium	2	FACU-

APPENDIX C

TRANSECT DATA AMONG SITES

APPENDIX C: TRANSECT DATA AMONG SITES

Transects were established at all study sites and species presence was recorded during three sampling periods (May, July, and November). Hillslope seeps were studied at the USACE site, the Fort Worth Nature Center and Refuge (FWNCR), and the LBJ Grasslands. Barrens were studied the USACE site and the FWNCR. Species highlighted in red are common to all study sites. The species highlighted in yellow are those common between the USACE site and the FWNCR. The species highlighted in blue are those common between the USACE site and LBJ Grasslands. Those highlighted in purple are those common between the FWNCR and the LBJ Grasslands.

Table 1: Comparison of transects on hillslope seeps among the study sites during May.

Hillslope Seep – May		
USACE	**FWNCR**	**LBJ Grasslands**
Ambrosia trifida	*Ambrosia trifida*	*Carex microdonta*
Bifora americana	*Bifora americana*	*Dichanthelium acuminatum* var. *lindheimeri*
Bromus arvensis	*Andropogon gerardii*	*Diospyros virginiana*
Calylophus berlandieri subsp. *pinifolius*	*Bouteloua hirsuta* cf. var. *hirsuta*	*Dysodiopsis tagetoides*
Carex microdonta	*Carex microdonta*	*Eleocharis montevidensis*
Centaurea americana	*Eleocharis occulta*	*Fimbristylis puberula* var. *puberula*
Cirsium undulatum	*Nassella leucotricha*	*Hedyotis nigricans*
Dichanthelium acuminatum var. *lindheimeri*	*Gaillardia pulchella*	*Helianthus maximiliani*
Eleocharis montevidensis	*Gaura suffulta*	*Juncus texanus*
Hedyotis nigricans	*Hedeoma reverchonii* var. *reverchonii*	*Marshallia caespitosa*
Iva angustifolia	*Mimosa roemeriana*	*Muhlenbergia reverchonii*
Juncus texanus	*Muhlenbergia reverchonii*	*Rhynchospora nivea*
Lythrum californicum	*Plantago patagonica*	*Rubus oklahomus*
Marshallia caespitosa	*Yucca pallida*	*Sorghastrum nutans*
Mimosa roemeriana		*Symphyotrichum ericoides*
Monarda citriodora		
Muhlenbergia reverchonii		
Rubus fruticosus		
Ruellia humilis		
Sisyrinchium angustifolium		

Hillslope Seep – May: Continuation of Table 1		
USACE	**FWNCR**	**LBJ Grasslands**
Sporobolus compositus var. *drummondii*		
Symphyotrichum ericoides		
Teucrium canadense		

Table 2: Comparison of transects on hillslope seeps among the study sites during July.

Hillslope Seep - July		
USACE	**FWNCR**	**LBJ Grasslands**
Ambrosia trifida	*Ambrosia trifida*	*Diospyros virginiana*
Andropogon gerardii	*Bouteloua hirsuta* var. *hirsuta*	*Eleocharis montevidensis*
Asclepias stenophylla	*Bromus arvensis*	*Helianthus maximiliani*
Bromus arvensis	*Carex microdonta*	*Iva angustifolia*
Carex microdonta	*Eleocharis occulta*	*Juncus texanus*
Cenaturea americana	*Gaillardia pulchella*	*Muhlenbergia reverchonii*
Cirsium undulatum	*Muhlenbergia reverchonii*	*Rhynchospora nivea*
Croton monanthogynus		*Rubus oklahomus*
Dicanthelium acuminatum var. *lindheimeri*		
Hedyotis nigricans		
Iva angustifolia		
Lippia nodiflora		
Muhlenbergia reverchonii		
Neptunia lutea		
Ruellia humilis		
Schizachyrium scoparium		
Sorghastrum nutans		
Symphyotrichum ericoides		
Teucrium canadense		

Table 3: Comparison of transects on the hillslope seep among the study sites during November.

Hillslope Seep - November		
USACE	**FWNCR**	**LBJ Grasslands**
Ambrosia trifida	*Andropogon gerardii*	*Bouteloua hirsuta* var. *hirsuta*
Bothriochloa laguroides	*Bouteloua hirsuta* var. *hirsuta*	*Eleocharis montevidensis*
Centaurea americana	*Croton monanthogynus*	*Eragrostis curtipedicellata*
Cirsium undulatum	*Eleocharis occulta*	*Euthamia gymnospermoides*
Croton monanthogynus	*Eragrostis curtipedicellata*	*Fimbristylis puberula* var. *puberula*

Hillslope Seep – November: Continuation of Table 3		
USACE	**FWNCR**	**LBJ Grasslands**
Dicanthelium acuminatum var. *lindheimeri*	*Gutierrezia texana*	*Gaillardia aestivalis* var. *flavovirens*
Gutierrezia texana	*Iva angustifolia*	*Iva angustifolia*
Hedyotis nigricans	*Liatris glandulosa*	*Liatris glandulosa*
Iva angustifolia	*Muhlenbergia reverchonii*	*Muhlenbergia reverchonii*
Lippia nodiflora	*Palafoxia callosa*	*Rhynchospora nivea*
Muhlenbergia reverchonii	*Schizachyrium scoparium*	*Scleria verticillata*
Ruellia humilis	*Yucca pallida*	*Sorghastrum nutans*
Schizachyrium scoparium		*Yucca arkansana*
Sorghastrum nutans		
Spiranthes cf. *ovalis*		
Sporobolus compositus var. *drummondii*		
Symphyotrichum ericoides		
Teucrium canadense		

Table 4: Comparison of barrens areas between the USACE and the FWNCR during May. No barrens were sampled at the LBJ Grasslands.

Barrens – May	
USACE	**FWNCR**
Ambrosia trifida	*Bromus arvensis*
Andropogon gerardii	*Castillegia indivisa*
Bifora americana	*Eleocharis occulta*
Bromus arvensis	*Gaillardia pulchella*
Calylophus berlandieri subsp. *pinifolius*	*Hedyotis nigricans*
Castillegia indivisa	*Monarda citriodora*
Centaurea americana	*Muhlenbergia reverchonii*
Gaillardia pulchella	*Plantago patagonica*
Gaura suffulta	
Hedeoma reverchonii var. *reverchonii*	
Hedyotis nigricans	
Mimosa roemeriana	
Monarda citriodora	
Muhlenbergeria reverchonii	
Opuntia phaeacantha	
Plantago patagonica	
Plantago wrightiana	
Salvia texana	
Schizachrium scoparium remnants	
Sporobolus compositus var. *drummondii*	
Symphyotrichum ericoides	
Tetraneuris linearifolia	
Yucca arkansana	

Table 5: Comparison of barrens areas between the USACE and the FWNCR during July. No barrens were sampled at the LBJ Grasslands.

Barrens - July	
USACE	**FWNCR**
Ambrosia trifida	*Ambrosia trifida*
Amsonia ciliata var. texana	*Bouteloua hirsuta* var. *hirsuta*
Andropogon gerardii	*Evolvulus nuttallianus*
Asclepias stenophylla	*Hedyotis nigricans*
Bromus arvensis	*Iva angustifolia*
Croton monanthogynus	*Liatris aestivalis*
Dicanthelium acuminatum var. *lindheimeri*	*Muhlenbergia reverchonii*
Erygium leavenworthii	*Psoralidium tenuflorium*
Hedeoma reverchonii var. *reverchonii*	*Schizachyrium scoparium*
Hedyotis nigricans	
Muhlenbergia reverchonii	
Opuntia phaeacantha	
Plantago wrightiana	
Rosa foliolosa	
Salvia texana	
Schizachyrium scoparium	
Yucca arkansana	

Table 6: Comparison of barrens areas between the USACE and the FWNCR during November. No barrens were sampled at the LBJ Grasslands.

Barrens - November	
USACE	**FWNCR**
Ambrosia trifida	*Castillegia indivisa*
Bouteloua hirsuta var. *hirsuta*	*Croton monanthogynus*
Chamaesyce missurica	*Dicanthelium oligosanthes* var. *scribnerianum*
Cirsium undulatum	*Eleocharis occulta*
Croton monanthogynus	*Eragrostis curtipedicellata*
Gutierrezia texana	*Muhlenbergia reverchonii*
Hedyotis nigricans	*Sporobolus compositus* var. *drummondii*
Liatris glandulosa	
Muhlenbergia reverchonii	
Opuntia phaeacantha	
Rosa foliolosa	
Schizachrium scoparium	
Sorghastrum nutans	

APPENDIX D

SOIL PIT PHOTOS

APPENDIX D: SOIL PIT PHOTOS

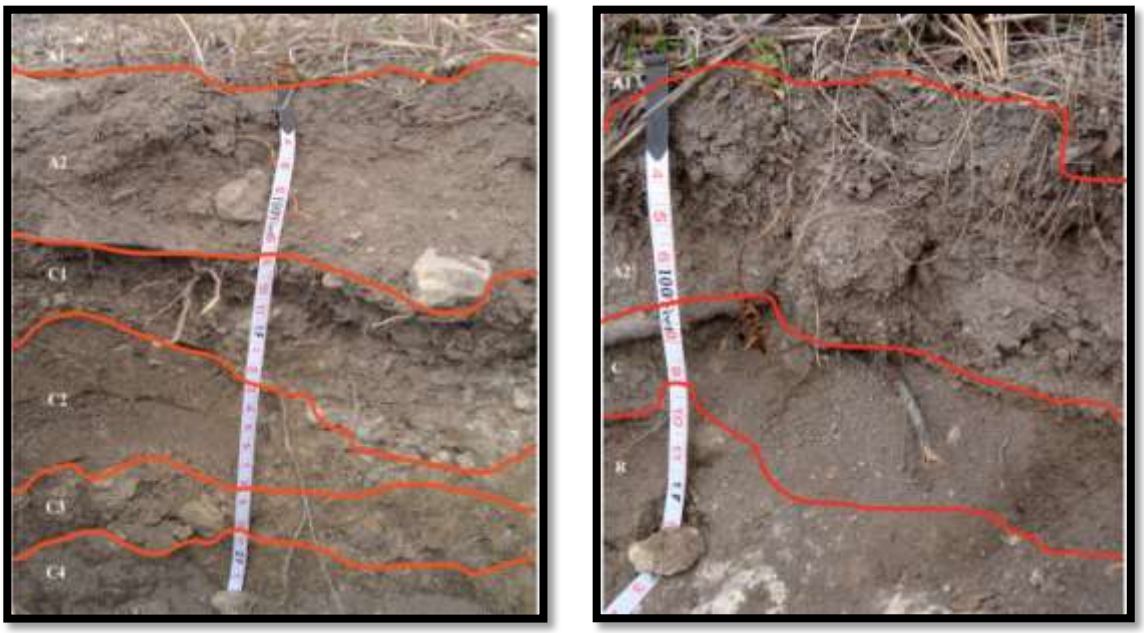

Figure 1: Soil Pit 1 (SP1), located on hillslope of seep. Marks the contact area between the limestone and marl layers. SP1-West (left) has much deeper soils than SP1-East (right).

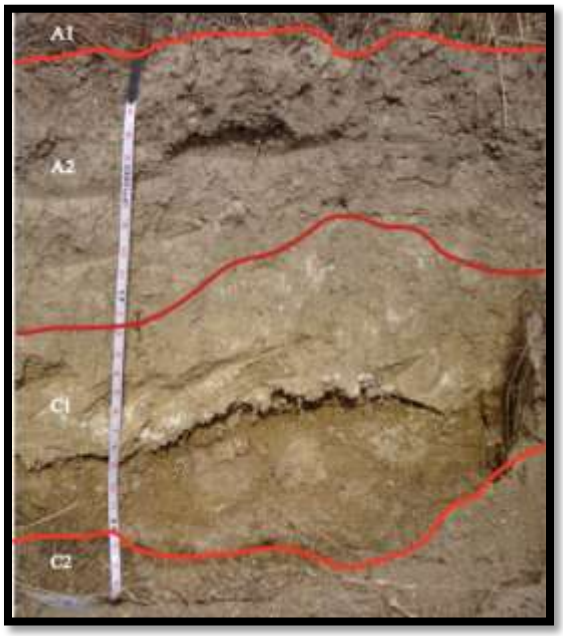

Figure 2: Soil Pit 2 (SP2), located in depression or hollow of seep.

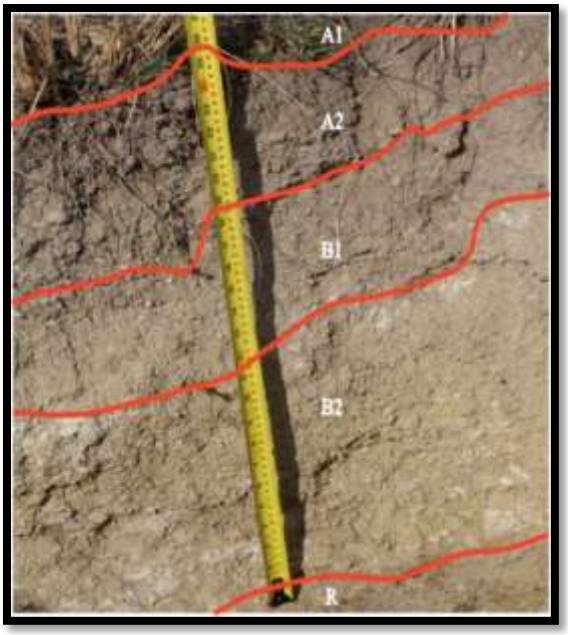

Figure 3: Soil Pit 3 (SP3), located in *Schizachyrium scoparium* patch, east of the barrens.

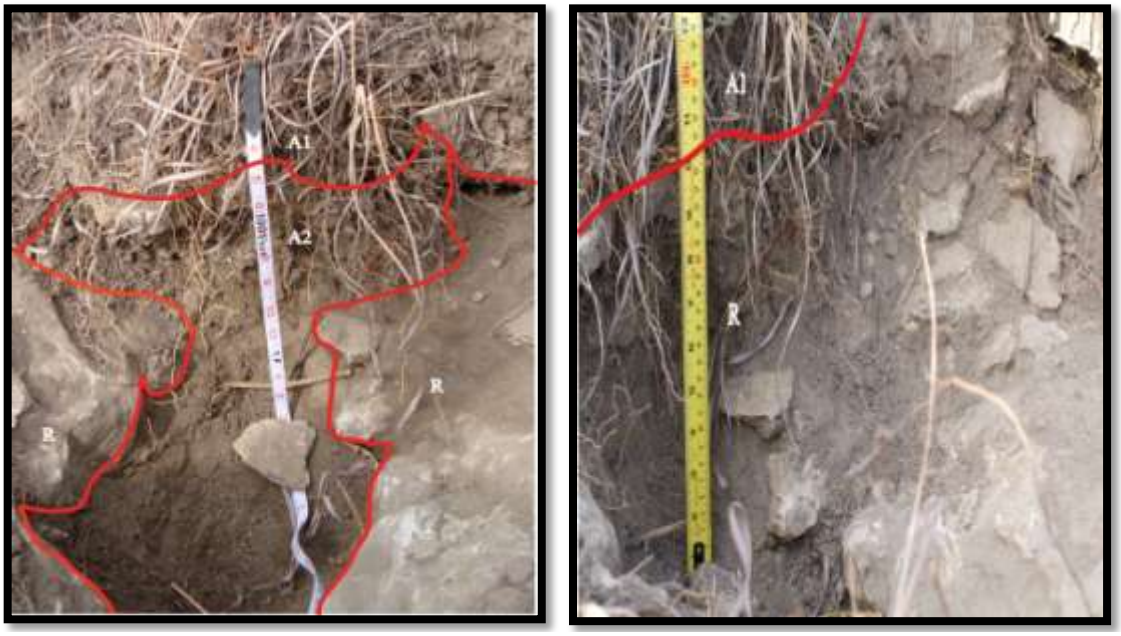

Figure 4: Soil Pit 4 (SP4), located at the western border of the barrens. Marks the contact between the limestone and marl layers. SP4-West (left) has much deeper soils than SP4-East (right).

Figure 5: Soil Pit 5 (SP5), located in *Andropogon gerardii* patch, west of the barrens.

Figure 6: Soil Pit 6 (SP6), located in *Andropogon gerardii* patch. Deeper soils than SP5.

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VITA

Melissa Lia-Yian Jue was born March 30, 1987, in Arlington, Texas to Do Har and Emily Jue. Melissa graduated from the University of Texas at Arlington in 2009 with a major in Environmental Biology and a minor Geology. During her time at the University of Texas at Arlington, Melissa worked in the Office of Informational and Instructional Resources.

In August 2009, Melissa enrolled at Texas Christian University to pursue a Master of Science in Environmental Science under the tutelage of Dr. Tony Burgess and Dr. Mike Slattery of TCU. During her time there, Melissa taught three semesters of Introduction to Contemporary Environmental Issues as a Graduate Teaching Assistant and assisted upper level undergraduate and graduate students with critical analysis writing for one semester.

Upon graduation, Melissa will join her fiancée Nic in Houston.

ABSTRACT

VEGETATIVE ANALYSIS OF MUHLY HILLSLOPE SEEPS IN NORTH CENTRAL TEXAS

by Melissa L. Jue, M.S., 2011
Department of Environmental Science
Texas Christian University

Thesis Advisor: Michael Slattery, Professor of Environmental Science

This study describes the vegetation and soils of one Muhly seep toposequence and compares species compositions between three study sites in North Central Texas. *Muhlenbergia reverchonii, Carex microdonta,* and either *Eleocharis montevidensis* or *Eleocharis occulta* are species found on every Muhly seep, particularly in depression areas. *Muhlenbergia reverchonii* is present but not always dominant species in the barrens. Bands of *Schizachyrium scoparium* and *Andropogon gerardii* are found in areas with deep, well-drained soils that are topographically higher and lower than hillslope seeps. Muhly seeps meet the hydrologic criterion for wetlands delineation but only certain sections meet the hydrophytic criterion. Hydric soils were not present, although ephemerally hydric soils may exist. As such, Muhly hillslope seeps are not protected under by the USACE, although they may be classified as a new type of wetland: a hyperseasonal wetland. Further research is required to determine the impact of Muhly seeps on prairie ecosystems.