Evaluation of Ecological Site Classes and Community Classes for Regional Scale Modeling of Conservation Effects on Grazing Lands: MLRA 77E

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Report date: March 17, 2017

INTRODUCTION

The Grazing Lands Component of the Conservation Effects Assessment Project (CEAP-GL) is evaluating the development and use of Ecological Site Classes and Community Classes within Major Land Resource Areas for regional and national scale modeling of conservation effects. National Resources Inventory (NRI) data is correlated to proposed Ecological Site Classes to provide data for the Agricultural Policy/Environmental eXtender (APEX) model and other models. The Rangeland Hydrology and Erosion Model (RHEM) is used to assess runoff and erosion differences between Community Classes.

CLASSIFICATION HIERARCHY AND DEFINITIONS

Ecological Site Class

Ecological Site Classes are proposed subdivisions of a Major Land Resource Area (MLRA) or Land Resource Unit (LRU). They are similar in concept to a general soil survey map unit – a general grouping of ecological sites by major landforms and vegetation types. An Ecological Site Class differs from other kinds of land in the kinds and amounts of vegetation produced, in the responses to disturbances, in recovery mechanisms, and management responses.

Plant Functional Groups

The Plant Functional/Structural Group indicator is defined in Interpreting Indicators of Rangeland Health (version 4) as, "*A suite or group of species that because of similar shoot or root structure, photosynthetic pathways, nitrogen fixing ability, life cycle, etc., are grouped together on an ecological site basis.*"

The presence, dominance and relative proportions of plant functional groups affect soil, hydrologic and biotic variables including:

- the kinds and amounts of canopy and foliar cover
- amount and arrangement of bare ground and litter cover
- plant spacing and amount of basal cover
- runoff and erosion rates
- structure and arrangement of vegetation which then influences the potential to carry fire and regulate fire intensity
- grazing preferences and distribution
- wildlife habitat values

The change in presence, dominance and/or proportion of plant functional groups is the primary attribute used to characterize States and Community Phases within an Ecological Site Description. Standardized plant functional groups were developed based on growth forms and flowering period. All plant species found in the MLRA were assigned to a plant functional groups. Non-native species were assigned to functional groups designated with (I) - for introduced. Production by functional group was then calculated for each NRI Primary Sampling Unit (PSU) community in the MLRA.

Community Class

A Community Class is a proposed plant community classification for an Ecological site class. The name of the Community Class is derived using the seven (7) dominant plant functional groups, listed in descending order by annual aboveground production on a dry weight basis. A Community Class is differentiated from other Community Classes by the presence and relative dominance of plant functional groups, and/or by significant differences in annual production. Refer to Appendix D for a list of common species and their assigned functional groups used for this project.

Plant Community

An actual plant community found at a given location, at a point in time.

Figure 1. MLRA 77E Limy Upland ecological site.

MAJOR LAND RESOURCE AREA 77E, SOUTHERN HIGH PLAINS, BREAKS

MLRA 77E occurs in the Texas Panhandle, crossing the 100th Meridian and turning north into Oklahoma, and the southwestern edge of Kansas. The MLRA is just over 6.6 million acres in size (27,735 square kilometers). The Canadian and Beaver Rivers are the major streams. The MLRA is characterized by moderately sloping plains, sand hummocks, and rocky escarpments formed in the Ogallala Geologic Formation. Elevations range from 2200 feet (670 meters) to 4800 feet (1465 meters) above mean sea level. This area is part of the Central Great Plains Winter Wheat and Range Land Resource Region (LRR H).

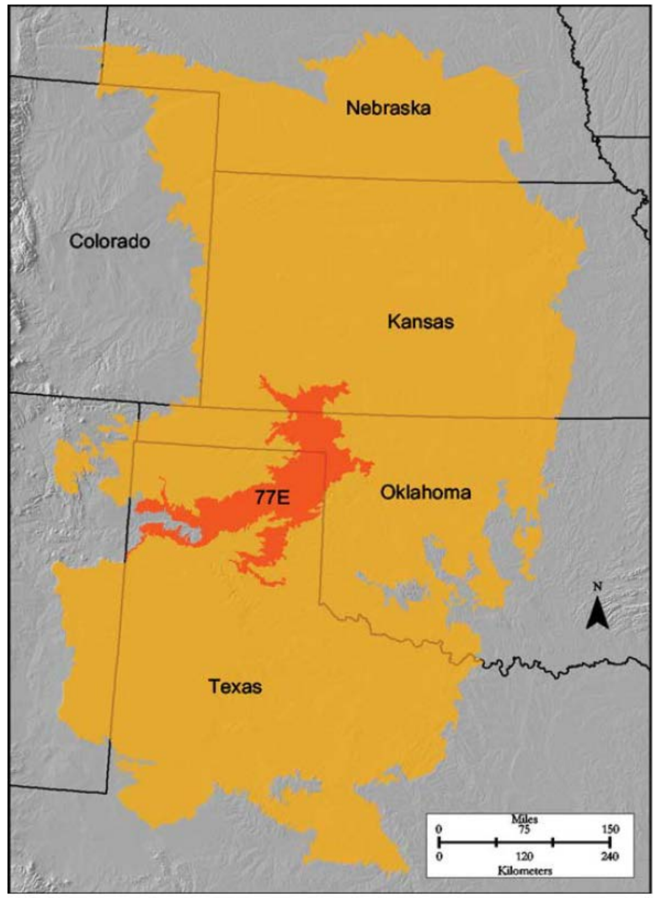

Figure 2. LRR H and MLRA 77E map. Source: Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296 (2006).

Plant communities in this Major Land Resource Area are a mixture of open grasslands and mixed grass – shrub communities. Important perennial grasses include blue grama, buffalograss, sideoats grama, and little bluestem. Tallgrasses such as sand bluestem and big bluestem occur with sand sagebrush, skunkbush sumac, and shinnery oak on the sandier soils. Other common shrubs include yucca, prickly pear, winterfat, and broom snakeweed. Honey mesquite is common south of the Canadian River. Refer to Appendix E for scientific plant names and additional plant classification data used throughout.

Climate

The following climate information is from the Limy Upland 16-24" PZ Ecological Site Description and characterizes the climate in MLRA 77E.

The climate is semiarid continental with hot summers and relatively mild winters. Temperature extremes are common. Humidity is low and evapotranspiration high. Short term dry spells are common and long term droughts occur every 20 to 25 years. Winds are predominantly southwesterly and average 12 mph for the year. Winds are highest in March and April. In winter, cold fronts are common and extreme drops in temperature occur within a few hours. Severe cold spells seldom last more than a few days. Approximately 70% of the precipitation occurs between May and October. Rainfall events often occur as intense storms of short duration. Snowfall averages 17 inches but is highly variable from year to year. For detailed information and specific climate stations of interest, visit the Western Regional Climate Center website at http://www.wrcc.dri.edu/ .

Averages

Frost-free period (days):	172
Freeze-free period (days):	197
Mean annual precipitation (inches):	23.27

Table 1. Monthly Precipitation (Inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	1.00	1.14	2.47	2.62	3.81	4.83	3.41	3.68	2.95	2.71	1.61	1.25
Medium	0.50	0.56	1.58	1.38	2.63	3.31	2.22	2.49	1.90	1.37	0.58	0.53
Low	0.12	0.15	0.88	0.67	1.76	1.92	1.27	1.56	0.85	0.53	0.23	0.21

Table 2. Monthly Temperature (°F)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	49.9	53.5	61.9	71.3	79.8	88.5	93.5	92.5	84.5	73.1	60.8	49.3
Low	22.1	25.1	32.9	41.8	52.6	62.1	66.8	65.8	57.0	44.6	32.2	23.0

The soil temperature regime is thermic and the soil moisture regime is ustic.

Representative Climate Stations

(1) CANADIAN [USC00411412], Hemphill County TX 79014. Period of record 1981-2010*
(2) GATE [USC00343489], Beaver County OK 73844. Period of record 1981-2010
*This climate station was used for the Rangeland Hydrology and Erosion Model (RHEM) evaluations.

AGRICULTURAL OPERATIONS

Agricultural producers in MLRA 77E typically raise both crops and livestock. The kind and size of operations are variable. The 100th meridian divides this MLRA and represents a general boundary between dryland cropland to the east and irrigated cropland to the west. Operation sizes and irrigation needs increase from east to west as precipitation decreases.

The major crops grown include wheat, corn, grain sorghum, cotton, soybeans, sunflower and canola. Corn is planted April or May and harvested in August and September. Grain sorghum is planted from April through June and harvested from September through November. Wheat is planted during from mid-September through mid-October, and then harvested from late May to early July. Cotton is planted mid-May to mid-June and harvested from mid-October through November. Wheat yields average 20-30 bu/ac. Corn yields average about 180 bu/ac Grain sorghum yields average from 20 bu/ac non-irrigated to 50 bu/ac irrigated. Cotton yields average 1.5 to 2 bales/ac Irrigation wells are generally 150 to 300 feet deep.

A "typical" operation toward the eastern side of the MLRA would be 1000 acres, with 200-300 acres in cropland and the rest as native rangeland and/or reseeded cropland that is in the Conservation Reserve Program. Livestock are grazed on the native rangelands primarily during the spring and summer growing season, while crops are being planted and harvested. Livestock graze on some combination of rangeland, wheat fields, crop residues or they may be fed on dry lots during the winter. Wheat fields are typically grazed October through March. Common cattle breeds are black and red Angus, Hereford and Charolaise. Weaning weights average 450 lbs for heifers and 550 lbs for steers. Early calving is done around April 1. Late calving is done in late June through early July.

RESOURCE MANAGEMENT SYSTEMS

Conservation Practices Applied

The following table shows the kinds and amounts of conservation practices that the landowners in MLRAs 77A-E are investing in on grazing lands. The table shows the most common conservation practices applied with NRCS assistance on grazed rangeland during fiscal years 2006-2011.

Table 3. Conservation practices applied from 2006-2011 (NRCS).

Practice Code	Practice Name (units)	Practice Count	Amount Applied	Acres Benefitted
528	Prescribed Grazing (ac)	8,651	5,797,687	5,836,137
645	Upland Wildlife Habitat Management (ac)	7,313	5,561,068	5,519,844
314	Brush Management (ac)	1,728	536,394	1,551,918
614	Watering Facility (no)	1,330	19,134	1,619,779
382	Fence (ft)	833	5,415,119	1,029,846
516	Pipeline (ft)	720	3,131,895	824,863
533	Pumping Plant (no)	371	377	459,372
642	Water Well (no)	322	891	344,173
550	Range Planting (ac)	317	23,517	80,947
643	Restoration and Mgmt of Rare and Declining Habitats (ac)	77	19,364	39,511
648	Wildlife Watering Facility (no)	23	230	15,916
378	Pond (no)	21	24	18,200
338	Prescribed Burning (ac)	12	2,143	5,976

Prescribed Grazing

Prescribed grazing is the most common conservation practice applied to address resource concerns on rangelands in this MLRA. Continuous heavy grazing reduces the tallgrass and midgrass and components of the plant communities, moving plant communities to shortgrass and shrub dominated communities. Conservative stocking rates range from 20 to 40 acres per animal unit, with higher stocking rates occurring in the eastern portion of the MLRA, due to higher rainfall amounts and increased forage production. Rotational grazing systems are not typically used in this MLRA. Livestock are typically moved seasonally, from winter use areas to summer use areas, in association with cropping patterns, crop residue grazing and winter feeding. A common strategy is to defer grazing for 90 days during the growing season at least every 3 to 4 years to restore the vigor of forage species. A full year of rest may be provided on areas needing more recovery time.

Watering Facilities

Most livestock water is provided by wells. Livestock wells are typically 50 to 300 feet deep. Livestock pipelines, storage tanks and troughs are used to distribute grazing and provide water to wildlife. Ponds generally do not provide a reliable water source because of the sandy soils.

Brush Management

The invasive woody species targeted for brush management in this MLRA are typically saltcedar, sand sagebrush, honey mesquite, yucca, and prickly pear. Most brush management is done using chemicals.

- Saltcedar is normally treated with imazapyr active ingredient. The Cooperative Extension Service recommendation is a 1 to 2% concentration mixed with water. The salt edar is sprayed in late summer to early fall before the leaves start turning yellow.
- Sand sagebrush is controlled occasionally with 2, 4-D. The Extension Service recommendation is 1-2 qts/ac for broadcast or a 1% mixture for individual plant treatment.

- Honey mesquite is controlled using a broadcast spray of aminopyralid plus clopyralid at a 1:4.6 ratio at the rate of 28 oz/ac which achieves 50-75% control. The application period starts in the spring when leaves change color to a dark green, and the soil temperature is above 75 degrees at 12-18 inches deep, and ends in September. Using a cut stump treatment is also very effective for mesquite control.
- Yucca species are controlled using individual plant treatments (IPT). Metsulfuron methyl and chlorosulfuron applied at 1 oz/ac or metsulfuron methyl, dicamba and 2,4-D at 32 oz/ac are recommended by the Texas Cooperative Extension Publication RM-1466.
- Prickly pear control recommendations from Cooperative Extension include picloram at 1 pint to 1 quart per acre for broadcast (1% solution for individual plant treatment) or using picloram:2,4-D (1:4 ratio) at 1 gallon per acre for broadcast or (2% solution for individual plant treatment).

Range Planting

Range planting is not common in MLRA 77E. There is typically a sufficient seed source for the desirable species to become re-established with good grazing management. With normal rainfall, reestablishment can occur in one year. Smooth brome occurs in some of the plant communities. This species was introduced into this area in the late 1800s, and became established following the Dust Bowl years, due to its resistance to drought. It is a cool season rhizomatous grass that competes with the native grasses.

Prescribed Burning

Prescribed Burning is not commonly used in this MLRA, but it plays a major role the ecology of the shortgrass prairie. Without fire, woody species can increase and can become dominant on several sites. Fire stimulates grass growth and promotes a greater diversity of forbs, which attracts wildlife such as pronghorn antelope and mule deer. The natural fire return interval is thought to be about 10 to 15 years.

Fencing

Standard barbed wire fencing using five (5) wires is the typical fencing used for livestock control. Fence markers are installed for the lesser prairie chicken.

Herbaceous Weed Control

This practice is being used to control noxious weeds such as wavyleaf thistle which has invaded the Texas panhandle over the last decade. A variety of herbicides are effective including 2,4-D. Treatment is recommended in the rosette stage.

Upland Wildlife Habitat Management

Wildlife includes deer, antelope, greater prairie chicken, bobwhite quail, pheasant and geese. Prescribed grazing and watering facilities provide the most common habitat improvements for wildlife species. The Canadian River has been designated as critical habitat for the Arkansas River Shiner, which is listed as Threatened by the U. S. Fish and Wildlife Service. This MLRA is also an important stronghold for the lesser prairie chicken which was listed by the U. S. Fish and Wildlife Service in 2014 and then delisted by court order in July of 2016.

ECOLOGICAL SITE CLASSES AND COMMUNITY CLASSES

In January 2016, there were thirteen (13) ecological sites correlated to soil map unit components in MLRA 77E. Those have been grouped into seven (7) Ecological site classes by working with the State and local NRCS soil and rangeland management scientists in MLRA 77E. Grouping was based on landscape position, soil characteristics, plant community composition, plant production and the response to climate, disturbance, use, and management.

Breaks Ecological Site Class

- Breaks 16-24" PZ R077EY062TX
- Very Shallow 16-24" PZ R077EY068TX

Bottom Ecological Site Class

- Draw 16-24" PZ R077EY052TX
- Loamy Bottomland 16-24" PZ R077EY058TX
- Sandy Bottomland 16-24" PZ R077EY065TX

Clayey Upland Ecological Site Class

- Clay Loam 16-24" PZ R077EY051TX

Limy Upland Ecological Site Class

- Hardland Slopes 16-24" PZ R077EY055TX
- Limy Upland 16-24" PZ R077EY057TX

Rocky Slopes Ecological Site Class

- Gravelly 16-24" PZ R077EY053TX
- Mixedland Slopes 16-24" PZ R077EY061TX

Sandy Upland Ecological Site Class

- Sandy 16-24" PZ R077EY064TX
- Sandy Loam 16-24" PZ R077EY066TX

Wet Bottomland Ecological Site Class

- Wet Bottomland 16-24" PZ R077EY571TX

Each NRI Primary Sampling Unit (PSU) in the Major Land Resource Area was correlated to a Community Class where possible. PSU data were not used when the species present or vegetative production was questionable. Additional Community Classes that are not currently represented in the ecological site descriptions were added when present in the NRI data (these most commonly were non-native dominated communities). Community Class names are derived using the top seven (7) plant functional groups, listed in descending order of annual aboveground air-dry production. The production for the plant functional groups is calculated from the NRI PSUs that are correlated to the Community Class. Refer to Appendix E for plant taxonomy.

All species and plant community production shown as pounds per acre (lbs/ac) in the following ecological site class descriptions refers to annual aboveground production, air-dried.

BOTTOM ECOLOGICAL SITE CLASS

Figure 3. General view, MLRA 77E Bottoms and Draws.

General Description

The Bottom ecological site class occurs in the lower portions of the landscape in areas which receive run-on from adjacent uplands and/or occasional to frequent flooding. Surface water and/or subsurface flows may be present from several hours to several weeks following rainfall events or snowmelt. There is not a seasonal or year-round shallow water table associated with this Ecological site class. Potential plant community production is higher than that of adjacent uplands, and the response to management may be more rapid because of the availability of additional run-on water. This ecological site class is very high in wildlife diversity.

Geomorphic Features

Landscape Positions:	Floodplains, Drainageways
Slope (percent):	0-2

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Alluvium
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam to Loamy Sand
Surface Texture Modifier:	None to Gravelly
Subsurface Texture Group:	Loamy to Sandy
Drainage Class:	Well Drained to Excessively Well Drained
Permeability Class:	Moderately Slow to Moderately Rapid
Chemistry:	None
Available Water Capacity:	2-12 inches

State and Transition Model

1. Perennial - Annual Herbaceous 1.1 Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Perennial Forb, Summer Annual Forb 2860 lbs/ac	1 to 2: Continuous heavy grazing, drought, lack of fire 2 to 1: brush management, prescribed burning, prescribed grazing	**2. Herbaceous – Woody** 2.1 Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Perennial Forb, Spring Annual Forb, Summer Annual Forb 3000 lbs/ac
1 to 4: plow, disk, plant	2 to 4: plow, disk, plant	2 to 3: prescribed grazing, lack of fire or brush management 3 to 2: brush management, prescribed burning, range planting, prescribed grazing
4. Cultivated Cropland **Average County Yields** Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	3 to 4: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass 4445 lbs/ac
4 to 6: abandonment 6 to 4: plow, disk, plant	4 to 5: range planting, prescribed grazing 5 to 4: plow, disk, plant	3 to 5: brush management, range planting, prescribed grazing 5 to 3: Continuous heavy grazing, lack of fire or brush management
6. Abandoned Cropland 6.1 Annual Forb, Perennial Forb, Summer Shortgrass, Summer Midgrass 300 lbs/ac	6 to 5: range planting, prescribed grazing	**5. Seeded Rangeland** 5.1 Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 2000 lbs/ac

Figure 4. State and Transition Model MLRA 77E Bottom ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 4) was derived from functional group production for the reference communities in the ecological Sites correlated to this ecological site class. The reference state of this ecological site class has an annual production of 2860 lbs/ac. Table 4 below shows the NRI values for Primary Sampling Units (PSUs) correlated to Community Class 1.1, as well as the other Community Classes. The Reference Community from the ecological site descriptions consists of tallgrass vegetation such as switchgrass, Indiangrass, sand bluestem, Eastern gamagrass, little bluestem, sideoats grama, western wheatgrass, hackberry, and Eastern cottonwood.

With heavy continuous grazing, no prescribed fire, and/or invasion of exotic species, the site is likely to transition to an herbaceous- woody state (2.1) in which western wheatgrass, little bluestem, sideoats grama, and sedges increase. Additionally, vegetation such as vine mesquite, composite dropseed, Canada wildrye, willow baccharis, and salt cedar may become present on the site. With moderate grazing and regular season deferment, prescribed fire, and mechanical or chemical brush management, the site may be returned to within reference characteristics (1.1). However, with further heavy continuous grazing, no prescribed fire or other brush management and invasion of exotic species, the site will likely concede to a shrub state (3.1). This state will have a loss of many species and a decrease in western wheatgrass, but increases of willow baccharis, tamarisk and the presence of purple threeawn. At this point, to return to a midgrass (2.1), 3-5 years of growing season deferment followed by moderate grazing, and/or chemical or mechanical brush management will be necessary.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 4. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using the Rangeland Hydrology and Erosion Model (RHEM).

Table 4. NRI Community Class Data and RHEM Results - MLRA 77E Bottom Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.2.1.1	Summer Tallgrass, Summer Perennial Forb, Summer Midgrass, Summer Annual Grass, Summer Shortgrass, Summer Annual Forb, Spring Perennial Forb	big bluestem (ANGE)(138), Cuman ragweed (AMPS)(134), Indiangrass (SORGH)(110), little bluestem (SCSC)(88), hairy grama (BOHI2)(80), Panicum spp (PANIC)(71), prairie broomweed (AMDR)(46)	1018	0.04	5.76	3
077E.2.2.1	Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Perennial Forb, Spring Annual Forb, Summer Annual Forb	Buffalograss (BODA2)(543), sideoats grama (BOCU)(491), western wheatgrass (PASM)(469), kochia (BASC5)(300), Cuman ragweed (AMPS)(154), Canadian horseweed (COCA5)(130), alkali sacaton (SPAI)(110)	3006	0.08	7.41	9
077E.2.3.1	Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass	golden currant (RIAU)(1638), Prunus spp. (PRUNU)(1344), Canada wildrye (ELCA4)(475), wingleaf soapberry (SASA4)(450), goldenrod (SOLID)(224), Buffalograss (BODA2)(105), Cuman ragweed (AMPS)(101)	4443	0.03	7.68	2

Supporting Information

The following publications support the State and Transition Model (STM). The first publication observed herbage production reduction with the use of herbicide, but found that varying soils had different results. The second publication found that stocking rate had little effect on the herbage production of the sites. However, the species composition was changed, and showed similar alterations as the STM.

Hughes, E.E. and R.A. Darrow. 1964. Herbage production responses to pelleted fenuron and granular 2,3,6-TBA. Journal of Range Management 17(4): 197-199.

This study was designed to measure the effects of soil surface applications of fenuron and 2,3,6-TBA at different rates and dates of application on native forage production on three ecological sites. The study area was on the Range and Forestry Area of the Texas Agricultural Experiment Station. The three sites included a sandy upland, prairie upland, and bottomland. The dominant grass species was little bluestem. The prairie upland vegetation showed some Texas wintergrass, and sideoats grama. The bottomland site had a dominant grass of brownseed paspalum. The fenuron and 2,3,6-TBA was hand broadcast on three dates in December, February, and April on each of the three sites. The experiment consisted of square rod plots in a randomized block design with three blocks on each site with a five-foot buffer zone. At the end of the study, herbage was clipped from 8 randomly selected square foot subplots and oven-dried.

The results found that on the sandy upland site, herbage production was not greatly affected by application of herbicides. On the prairie upland, 2,3,6-TBA appeared to reduce herbage production more than fenuron. On the bottomland site, treatments with 2,3,6-TBA caused a significant reduction in herbage production. Differences in the reaction to herbicides was likely due to differences in soils.

Gillen R.L., J.A. Eckroat, and F.T. McCollum III. 2000. Vegetation response to stocking rate in southern mixed-grass prairie. Journal of Range Management 53(5): 471-478.

This study was designed to measure the effect of cattle stocking rate on standing crop dynamics and species composition of a southern-mixed grass prairie. The study area was located southwest of Clinton, Oklahoma and was characterized by rolling uplands divided by moderately deep, steep-walled drainages. Major grass species included sideoats grama, blue grama, hairy grama, buffalograss, silver bluestem, red threeawn, purple threeawn, and little bluestem. Major forbs included western ragweed and curlycup gumweed. There was also scattered populations of broom snakeweed on shallow sites. This area had also been previously seeded with sand bluestem, little bluestem, Indiangrass, sideoats grama, and blue grama. The methods of this study employed stocking rates of 23, 26, 34, 41, 48, or 51 AUD/ha randomly allocated to 6 pastures. The current recommended sustainable stocking rate was 25 AUD/ha. The average pasture size was 65 ha and were continuously stocked. Herbage standing crop was measured each year by clipping 50 quadrats to ground level. The quadrats were systematically spread across each pasture along pace transects. Species composition was measured using the dry-weight rank method with 100 quadrats per pasture. For the statistical evaluation, an analysis-of-covariance model was employed. This model fit a linear regression between the dependent variable and stocking rate for each year.

The results found the total standing crop, averaged over stocking rates and years, was similar in July and September. Total standing crop and stocking rate had an inverse relationship because of greater total forage demand at higher stocking rates. Averaged over months, standing crop decreased approximately 17 kg/ha for every AUD/ha increase in stocking rate. This suggests that stocking rate did not affect the herbage production potential of these pastures during the study. Live standing crop varied among the years, ranging from 630 kg/ha to 1,410 kg/ha. Percentage live standing crop was significantly related to stocking rate in July and September. It increased by 0.4%h for each increase of 1 AUD/ha. Live standing crop ranged from a low of 28% to a high of 67%. Dead standing crop was related to stocking rate in both July and September. As stocking rate increased, the standing crop of head herbage decreased. Sideoats grama was the most abundant single species, comprising of approximately 20% of the vegetation, and was not affected by stocking rate. The short grasses were prominent in all pastures, contributing to approximately 25% of the vegetation, with buffalograss being the most abundant. Silver bluestem was the most abundant at higher stocking rates; its percentage composition was 6% and remained there for the entirety of the study. There was no relationship between threeawns and stocking rate in 1990. By 1996, threeawns had increased at all stocking rates, but was more abundant at lower stocking rates. Tallgrasses were negatively related to stocking rate and increased at lower stocking rates. Broom snakeweed was not affected by stocking rate. It did more than double from 1990 to 1992, but declined to near normal levels in 1996.

The conclusions of this study found that stocking rate had little impacts on the experimental pastures. Stocking rate did affect the relative species composition, specifically in tallgrasses and threeawn. It is likely that precipitation levels in combination with stocking rate will trigger vegetation changes. Additionally, it is likely that significant changes had occurred on this pasture in the 80 years that it had been grazed previously.

Additional Literature Pertinent to the STM

Cuomo, C.J., R.J. Ansley, P.W. Jacoby, and R.E. Sosebee. 1992. Honey mesquite transpiration along a vertical site gradient. Journal of Range Management 45(4): 334-338.

BREAKS ECOLOGICAL SITE CLASS

Figure 5. MLRA 77E Breaks ecological site class.

General Description

This site class occurs in an upland position. The site does not receive run-on moisture from adjacent sites. The site class is characterized as escarpments of calcareous sandstones and limestones, and their associated colluvial slopes. Soils are very shallow to very deep, gravelly to extremely stony loams and sandy loams. Site stability is controlled by bedrock. As erosion occurs, the gravels in the soil profile are exposed at the surface, helping to armor and protect the surface from wind and water erosion.

Geomorphic Features:

Landscape Position:	Ridges, Escarpments, Hills
Slope (percent):	2-40

Representative Soil Features

Soil Depth:	Very Shallow to Moderately Deep
Parent Material Kind:	Alluvium, Aeolian
Parent Material Origin:	Limestone, Dolomite
Surface Texture:	Loam to Sandy Loam
Surface Texture Modifier:	Gravelly to Extremely Gravelly
Subsurface Texture Group:	Loamy
Drainage Class:	Well Drained
Permeability Class:	Moderate to Impermeable
Chemistry:	Calcareous throughout
Available Water Capacity:	0.5-6 inches

State and Transition Model

1. Herbaceous - Woody		2. Woody - Herbaceous
1.1 Summer Midgrass, Summer Perennial Forb, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Summer Tallgrass, Deciduous Shrub 910 lbs/ac	1 to 2: continuous heavy grazing, lack of fire 2 to 1: chemical brush management, periodic fire, prescribed grazing	2.1 Deciduous Shrub, Evergreen Subshrub, Spring Perennial Forb, Monocot Shrub, Summer Midgrass, Spring Annual Forb, Evergreen Tree 2333 lbs/ac

Figure 6. State and Transition Model MLRA 77E Breaks ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 6) was derived from functional group production for the reference communities in the ecological site descriptions that were correlated to this ecological site class. The state and transition model for this ecological site class produces approximately 900 lbs/ac per year. Vegetation will likely consist of big bluestem, Indiangrass, sideoats grama, little bluestem, New Mexico feathergrass, black grama, silver bluestem, slim tridens, alderleaf mountain mahogany, featherplume, broom snakeweed, and oneseed juniper. With heavy continuous grazing and a limited fire, the site is likely to transition to a shrub/halfshrub state (2.1). The vegetation in this state would consist of purple threeawn, sand dropseed, soapweed yucca, broom snakeweed, skunkbush sumac, and oneseed juniper. To return to reference conditions chemical brush management followed by grazing to provide periodic growing season deferment and fire will be necessary.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 5. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM.

Table 5. NRI Community Class Data and RHEM Results - MLRA 77E Breaks Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.12.1.1	Summer Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Tallgrass, Spring Perennial Forb, Monocot Shrub	Buffalograss (BODA2)(348), little bluestem (SCSC)(281), blue grama (BOGR2)(232), hairy grama (BOHI2)(179), sideoats grama (BOCU)(165), big bluestem (ANGE)(73), Threeawn (ARIST)(53)	2009	0.35	13.77	21
077E.12.2.1	Deciduous Shrub, Evergreen Subshrub, Spring Perennial Forb, Monocot Shrub, Summer Midgrass, Spring Annual Forb, Evergreen Tree	shinnery oak (QUHA3)(380), Yucca spp. (YUCCA)(228), Rocky Mountain zinnia (ZIGR)(214), redberry juniper (JUCO11)(189), stemmy four-nerve daisy (TESC2)(142), lambsquarters (CHAL7)(136), trailing krameria (KRLA)(104)	2333	0.30	16.47	3

Supporting Information

The following publication supports the STM. Although the article discusses a broad base of Texas ecological sites, it implicates the same concepts. Essentially, with over-utilization it is difficult for a site to recover and is often subject to undesirable shrubs or weeds to thrive.

Young, Vernon. 1956. The effect of the 1949-1954 drought on the ranges of Texas. Journal of Range Management 9(3): 139-142.

This article examines the effect on the range of the 1949-1954 drought in Texas. This 5-year drought brought high temperatures, minimal rainfall, and great loss to vegetation cover. The vegetation loss led to loss of fertile topsoil and created wind erosion opportunities.

In the summer of 1954, vast areas of grassland were predicted to be 75 to 95 percent below their potential. When rain returned in the fall of 1954, topsoil was lost in the areas that were heavily utilized, often resulting in gully washes. The drought effect on brush was evident as well. Several trees died from stress, but those resistant to drought such as pricklypear and mesquite survived. Studies found that after the drought, many grass species died whether grazed or not. However, grasses such as curly-mesquite and buffalograss showed a 9% survival with heavy stocking rate, 12% survival with moderate stocking, 15% on light, and 22% survival with rotational grazing. On the rocky soils at the Sonora Ranch Experiment Station, curly-mesquite was established with the first rains in 1954 and made noticeable recovery in the following year. However, on the heavy soils 85 miles north, very few seedlings developed of curly-mesquite. But, the buffalograss, with a higher resistance to trampling, made decent recoveries. Data from the Texas Range Station found that tallgrasses were very scarce post-drought. On areas that supported significant amounts of brush, there was a greater likelihood of grasses and forbs surviving. This was especially seen on Hardland ecological sites with brush. However, many of these brush species were undesirable and continued to thrive post-recovery. Data from the Sonora Ranch Experiment Station in 1954 found that curly-mesquite had a 12% survival, sideoats grama was 97%, silver bluestem was 87%, and Wright's threeawn had 45% survival. Deep-rooted bunchgrasses did better than others, but perennial grasses at heavily utilized sites were too severely trampled to have new root development. On the sites that did not recover, weeds began to have rapid growth.

Overall, this 5-year drought was very damaging to Texas ecological sites, and can be correlated to soil types. It is evident that sites that were properly managed before and after the drought can be characterized at fair to good conditions. However, those that were overstocked were severely damaged and recovery has been minimal.

CLAYEY UPLAND ECOLOGICAL SITE CLASS

Figure 7. MLRA 77E Clayey Upland site recently treated to control honey mesquite.

General Description

The Clayey Upland ecological site class occurs on nearly level plains and upland terraces. The site does not benefit from run-on moisture. Soil surface textures are clay loams and clays. Slow infiltration rates limit the amount of precipitation that can infiltrate into the soil, especially when the vegetation cover is lost. Runoff is generally highest on this ecological site class. In the drier portions of this MLRA south of the Canadian River, honey mesquite invasion occurs primarily on this site.

Geomorphic Features

Landscape Position:	Plains, Terraces
Slope (percent):	1-5

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Alluvium
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam; Clay
Surface Texture Modifier:	None
Subsurface Texture Group:	Loamy
Drainage Class:	Well Drained
Permeability Class:	Moderate
Chemistry:	None to Slightly Saline
Available Water Capacity:	5-6 inches

State and Transition Model

1. Perennial – Annual Herbaceous 1.1 Summer Shortgrass, Summer Stoloniferous Grass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Summer Perennial Forb, Spring Perennial Forb 1510 lbs/ac	1 to 2: Continuous heavy grazing, drought, lack of fire 2 to 1: brush management, prescribed burning, prescribed grazing	**2. Herbaceous – Woody** 2.1 Spring Annual Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Midgrass, Spring Rhizomatous Grass, Summer Perennial Forb, Summer Shortgrass 1550 lbs/ac
1 to 4: plow, disk, plant	2 to 4: plow, disk, plant 3 to 1: brush management, prescribed burning, range planting, prescribed grazing	2 to 3: continuous heavy grazing, lack of fire 3 to 2: brush management, prescribed burning, range planting, prescribed grazing
4. Cultivated Cropland **Average County Yields** Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	3 to 4: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass 900 lbs/ac
4 to 6: abandonment 6 to 4: plow, disk, plant	4 to 5: range planting, prescribed grazing 5 to 4: plow, disk, plant	
6. Abandoned Cropland 6.1 Annual Forb, Perennial Forb, Summer Shortgrass, Summer Midgrass 600 lbs/ac	6 to 5: range planting, prescribed grazing	**5. Seeded Rangeland** 5.1 Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 1250 lbs/ac

Figure 8. State and Transition Model MLRA 77E Clayey Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 8) was derived from functional group production for the reference communities in the ecological site descriptions that were correlated to this ecological site class. The Clayey Upland ecological site class has a reference state that is a mixture of native grasses with a mesquite overstory. The native grasses include blue grama, buffalograss, and sideoats grama. With heavy continuous grazing, lack of fire, and/or brush encroachment, the site will transition to an herbaceous – woody state (2.1) in which the native grasses decrease and species such as threeawn, silver bluestem, honey mesquite, and yucca appear. There is also an increase of bare ground from 10% to 25%. The site may return within reference state conditions (1.1) with prescribed grazing, brush management, and/or prescribed burning. However, if these management practices are not implemented, and the site is subjected to long-term heavy continuous grazing, no fire, and/or continued brush encroachment, it is likely to transition to a shrub dominated state (3.1). This state will have increased honey mesquite and yucca, with bare ground reaching 50%. Simultaneously, there will be a decrease in threeawn, silver bluestem, blue grama, and buffalograss.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 6. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM. The average slope on the two PSUs correlated to community 2.1 is less than the average slope for the four PSUs correlated to community 1.1 (1% vs 3%) which likely accounts for most of the soil loss difference. See Appendix C for additional cover and erosion data.

Table 6. NRI Community Class Data and RHEM Results - MLRA 77E Clayey Upland Ecological Site Class

Comm Class ID	**Community Class**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.4.1.1	Summer Shortgrass, Summer Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb, Summer Annual Forb	blue grama (BOGR2)(555), Cuman ragweed (AMPS)(327), Buffalograss (BODA2)(296), silver bluestem (BOSA)(178), sand dropseed (SPCR)(78), woolly plantain (PLPA2)(58), annual buckwheat (ERAN4)(37)	1831	0.38	12.46	4
077E.4.2.1	Spring Annual Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Midgrass, Spring Rhizomatous Grass, Summer Perennial Forb, Summer Shortgrass	American star-thistle (CEAM2)(348), Buffalograss (BODA2)(186), Texas croton (CRTE4)(144), sideoats grama (BOCU)(112), purple monkeyflower (MILE2)(104), western wheatgrass (PASM)(99), vine mesquite (PAOB)(75)	1550	0.06	10.12	2

Supporting Information

The following publications support the information from the State and Transition Model (STM). The first publication concluded, as the STM predicted, that with lack of disturbance or management (in this case brush management), the site demonstrated a steady increase of mesquite. The second publication determined that there was no significant change in herbage production from brush removal, but that grazing and precipitation would have a significant effect. Additionally, the third publication examined methods of tilling and seeding sites that are in poor range condition. The fourth publication examined a site in poor range condition and found that brush removal was crucial to the return of increased herbage production.

Ansley, R.J., X.B. Wu, and B.A. Kramp. 2001. Observation: Long-term increases in mesquite canopy cover in a north Texas savanna. Journal of Range Management 54(2): 171- 176.

During a 20-year period (1976-1995), research was conducted on a clay loam site in north Texas to quantify long-term rates of woody plant encroachment. The objective was to quantify the rate at which honey mesquite increased in canopy cover, using aerial photography. Comparisons were made between a root-plow treated site in which 95% of mesquite was eliminated and an adjacent untreated site. Dominant perennial grasses on the site included Texas wintergrass and buffalograss with a mesquite overstory. The root-plowed area was seeded to sideoats grama. Both sites had been grazed by cattle for the previous 50 years, which was discontinued 12 years into the study. The sites were aerial-photographed using color-infrared film at low altitude in 1976 (the first year of the study), 1990, and 1995 (the last year of the study). These images were scanned and georeferenced with control points collected. The images were set on a fixed grid pattern with mesquite canopies delineated with a digitized line, then evaluated using the line intercept method. Attributes of patch density, patch size, patch shape index, and nearest neighbor distance were measured. During the study, there were 11 years of above average precipitation and one extended drought that killed large areas of buffalograss. Results showed that mesquite cover increased in the untreated area from 14.6 to 58.7% during the 20-year period. Mesquite cover also increased in the root-plowed site from 0% to 21.9%, but was significantly lower than that of the untreated. Percent cover of herbaceous composition differed in the two areas because of seeding after root-plowing. Toward the end of the study, the dominant species in the untreated area were Japanese brome and Texas wintergrass. The dominant species in the root-plowed area were Texas wintergrass, sideoats grama, and Japanese brome. The mean patch size in the untreated site increased gradually from 1976 to 1990, with a sharp increase from 1990 to 1995. The root-plowed site showed very minimal increase until 1990, in which it began a very slow increase.

The results of this study led to the conclusion that mesquite areas increased over time, with untreated sites increasing more rapidly. Additionally, rates were greater in both untreated and treated during years of above normal precipitation.

R.K. Heitschmidt, R.D. Schultz, and C.J. Scifres. 1986. Herbaceous biomass dynamics and net primary production following chemical control of honey mesquite. Journal of Range Management 39(1):67-71.

The objective of this study was to quantify the effects of the control of honey mesquite on species composition six (6) and seven (7) years after treatment. The study area was located south of Vernon, Texas in 1979 and 1980, with the first year having slightly above normal precipitation and the second being below average. Twice replicated 0.25 ha subplots were located on two 6.4 ha brush management treated plots from 1974 of range site classified clay loam soil. Treatments were an untreated control and an aerial application of a 1:1 mixture of 2, 4, 5,-T and picloram in diesel oil-water emulsion. The plots were grazed by cattle at a low stocking rate during each dormant season. In 1974, the native vegetation of the sites were classified prior to treatment and determined as 26% honey mesquite canopy with an average of 556 plants/ha. The understory vegetation was a mixture of short- and midgrass. Dominant short grasses were buffalograss, and little barley. Midgrasses dominating were Texas wintergrass, sand dropseed, white tridens, and red threeawn. In 1979, the estimated woody plant density on the untreated subplots was 963 plants/ha, compared to the 248 plants/ha on the treated. Average tree height in the untreated was 2.2m, compared to the 0.9 on the treated. The dominant herbaceous species in the plots were buffalograss, Texas wintergrass, little barley, and Japanese brome. For evaluation, the aboveground standing crop was sampled by frequent harvesting utilizing randomly placed quadrats. Vegetation was clipped at ground surface and dried at 140 degree Fahrenheit. All biomass was separated by species in the categories of live, recently dead (current year's dead), and old dead (previous year's dead). Harvest dates were approximately once a month. Belowground biomass was also sampled in June of both years to estimate vertical root distribution. Aboveground net primary production (ANPP) was estimated by summing peak current year's (live + dead) standing crop by species and species group. Data was analyzing using various analysis of variance models.

The results indicated that vegetative growth began in early spring of 1979, with peak standing crop occurring in June for both treatments. These peaks were estimated as 1,750 and 1,600 kg/ha for the untreated and treated plots. Peak live biomass in both treatments was approximately 40% less in 1980, than 1979. As the plants senesced in the summer months, the dead material increased. ANPP varied significantly between years and among species. During the 1980 drought, the ANPP reduced 27% relative to the 1979 estimates. The estimated root biomass was 3,837 kg/ha with differences between treatments and years not significant. The results of this study suggest no difference in total herbage production between sprayed and unsprayed honey mesquite plots 6 and 7 years post-treatment. This leads to the hypothesis that the herbage response following control of honey mesquite is often related to the response of the grasses growing beneath the canopy of the trees at the time of treatment. This suggests that control of sparse stands of mesquite and/or control of mesquite on sites with low productivity and/or in excellent range condition limit the magnitude of the herbage response post-treatment. However, rainfall patterns and grazing intensity generally affect both the magnitude and duration of the response.

Berg, William A. and Phillip L. Sims. 1984. Herbage yields and water-use efficiency on a loamy site as affected by tillage, mulch, and seeding treatments. Journal of Range Management 37(2): 180-184.

This study in Harper County, northwestern Oklahoma, examined tillage, sand and rock mulch treatments and combinations of these treatments with interseeding of introduced bluestem on a loamy range site in poor condition. The objective was to measure herbage yields as a function of the treatments that were applied in pursuit of increasing water-use efficiency. The plots were on a smooth slope with a history of moderate to heavy grazing and major droughts. The vegetation was dominated by buffalograss with lesser amounts of silver bluestem, blue grama, purple threeawn, sand dropseed, and sideoats grama. Japanese brome was also common in years of greater precipitation during the fall and winter. The range condition is considered poor because the majority of the herbage composition is buffalograss (an increaser) and by silver bluestem (an invader). The following treatments were applied to the native vegetation in April of 1976:

- Control. No treatment.
- Disking. Use of a heavy double disk severed approximately 50% of vegetation crown cover.
- Furrowing. Small furrows 5 cm deep and 10 cm wide made on a contour.
- Sand mulch. Two cm of medium and fine sand was placed directly on the vegetation.
- Disking + Sand Mulch.
- Furrowing + sand in furrows.
- Rock mulch. Flat, fine-textured sandstones were placed on the vegetation to give approximately 70% ground cover.
- Introduced bluestem + sand mulch. An introduced bluestem was broadcast at a rate of 2 kg/ha pure live seed with sand placed over it.
- Disking, introduced bluestem + sand mulch.
- Furrowing, introduced bluestem + sand in furrow.

Five replications were used and the plots were excluded from livestock. Each spring the vegetation was mowed with the exception of the rock mulch plots. Yields were measured by micro-unit (weight estimate method using 11.5 x 26 inch quadrats) forage inventory with a weight-estimate on twenty-four quadrats.

Results found that disking or furrowing of native range resulted in no significant changes to herbage yields compared to the control within the 5-year period. Furrowing plus sand-fill in the furrows or the rock mulch resulted in greater herbage yields than the control, likely because of an increase in the silver bluestem. Herbage yields from the 1977-1980 growing seasons were 2- to 4- fold greater on treatments inter-seeded into the introduced bluestem than on the native range treatments. The first year bluestem produced 29% of the herbage, with the consecutive years producing 72, 79, 84, and 92% of the herbage. There were no significant differences among the herbage yields on the three surface treatments combined with broadcast seeding. This study concluded that disking or furrowing of native range dominated by buffalograss and silver bluestem had no measurable effect on herbage yields or water-use efficiency. More intensive surface treatments did increase the yield of silver bluestem but not of more desired species. It is likely that seeding of desired midgrasses and control of the competition of buffalograss and silver bluestem will be necessary to increase forage production of native species on the site.

Bedunah, D.J., and R.E. Sosebee. 1984. Forage response of a mesquite-buffalograss community following range rehabilitation. Journal of Range Management 37(6): 483-487.

The purpose of this study was to evaluate changes in vegetation following several brush manaqement techniques on a deteriorated range site with high mesquite density. The mesquite-buffalograss dominated site in Post, Texas consisted of gently sloping uplands of clay loam with primarily shortgrasses and intermingled midgrasses. Climax decreasers included blue grama, sideoats grama, vine-mesquite, and western wheatgrass. Increasers included buffalograss, silver bluestem, tobosagrass, white tridens, and Texas wintergrass. Invaders included perennial threeawns, sand dropseed, hairy tridens, Texas grama, tumblegrass, prickly pear, cholla, mesquite, and lotebush. At the beginning of the study, the site was in low fair range condition and in a downward trend. Mesquite and buffalograss were the major overstory and understory dominants. The area had historically been grazed by cattle year long.

The study area was fenced and protected from large herbivore grazing for the duration of the study. Three rows of six 1 acre plots were located in completely randomized design with 3 replications/ treatment. The vegetation manipulation included: 1) shredding mesquite; 2) foliar spraying of mesquite (1:1 mixture of 2,4,5-Trichlorophenoxy-acetic acid + 4-amino-3,4,5,6-piclorlinic acid at 0.6 kg ai/ha); 3) mechanically grubbing mesquite; 4) mechanically grubbing mesquite between mesquite trees; 5) vibratilling (grubbing and raking); 6) seeding to kleingrass, and; 7) no treatment (control). Mesquite mortality (%) was measured by counting living trees in each plot before treatment and 3-years post-treatment. Herbage data (standing crop) was collected after each growing season by clipping 21 randomly located quadrats. Herbage was classified into 3 groups: 1) total grass production; 2) total forb production; 3) sum of standing crop (total production) of grasses and forbs. Ground cover percent was estimated ocularly for each quadrat by species and for litter before clipping.

The results found that all techniques had the immediate effect of eliminating the live mesquite canopy. Foliar application of herbicide resulted in 78% root kill, and 98% canopy cover reduction 3-years post-treatment. Mechanical grubbing caused top removal of all trees and 90% root kill. Grubbing with vibratilling or vibratilling with seeding resulted in 96% and 94% root kill 3-years post-treatment. Shredding severely suppressed the mesquite for the first season, but regrowth was evident the second season. In terms of herbage production, mesquite removal by all treatments increased herbage production and vegetative ground cover. This was likely because of reduced competition between mesquite and herbaceous plants. Grazing capacity was calculated at the end of the study and was found to have significantly increased with range rehabilitation practices. Seeding with kleingrass resulted in the greatest estimated capacity, with foliar spray and vibratilling treatments being very similar. This study concluded that all brush treatments were effective in reducing mesquite canopy cover 3-years post-treatment. These treatments resulted in an increase in herbage productivity and thus, grazing capacity. It found that seeding was necessary for depleted sites. Additionally, mechanical grubbing, followed by vibratilling decreased surface runoff and resulted in a longer control of mesquite. Shredding resulted in short term control. For deteriorated sites, a grazing deferment would be necessary to increase vigor of forage plants.

Additional Literature Pertinent to the STM

Heaton, C.B., X.B. Wu, and R.J. Ansley. 2003. Herbicide effects on vegetation spatial patterns in a mesquite savanna. Journal of Range Management 56(6): 627-633.

Heitschmidt, R.K. and S.L. Dowhower. 1991. Herbage response following control of honey mesquite within single tree lysimeters. Journal of Range Management 44(2): 144-149.

SANDY UPLAND ECOLOGICAL SITE CLASS

Figure 9. MLRA 77E Sandy Upland ecological site class.

General Description

This ecological site class occurs on gently sloping plains and rolling dunes. The soils are deep and sandy textured. The soils in this site class can capture most or all of the precipitation that falls, but water-holding capacity is limited. Wind erosion is the primary erosion concern on this Ecological site class if vegetation cover is lost.

Geomorphic Features

Landscape Position:	Dunes, Outwash Plains, Stream Terraces
Slope (percent):	1-15

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Outwash, Aeolian Deposits
Parent Material Origin:	Mixed
Surface Texture:	Fine Sandy Loam to Loamy Sand
Surface Texture Modifier:	None
Subsurface Texture Group:	Sandy
Drainage Class:	Well Drained to Excessively Drained
Permeability Class:	Moderately Rapid to Very Rapid
Chemistry:	None
Available Water Capacity:	2-6.5 inches

State and Transition Model

1. Perennial - Annual Herbaceous 1.1 Summer Perennial Forb, Summer Midgrass, Summer Tallgrass, Spring Perennial Forb, Spring Midgrass, Summer Annual Forb, Summer Rhizomatous Grass 2048 lbs/ac	1 to 2: Continuous heavy grazing, lack of fire 2 to 1: chemical brush management, prescribed burning, prescribed grazing	**2. Herbaceous – Woody** 2.1 Summer Midgrass, Summer Shortgrass, Spring Annual Forb(I), Monocot Shrub, Evergreen Shrub, Summer Rhizomatous Grass, Spring Perennial Forb 1980 lbs/ac
1 to 4: plow, disk, plant	2 to 4: plow, disk, plant 3 to 1: brush management, prescribed burning, range planting, prescribed grazing	2 to 3: continuous heavy grazing, lack of fire or brush management 3 to 2: chemical brush management, prescribed burning, range planting, prescribed grazing
4. Cultivated Cropland **Average County Yields** Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	3 to 4: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb 3223 lbs/ac
4 to 6: abandonment 6 to 4: plow, disk, plant	4 to 5: range planting, prescribed grazing 5 to 4: plow, disk, plant	
6. Abandoned Cropland 6.1 Annual Forb, Perennial Forb, Summer Shortgrass, Summer Midgrass 300 lbs/ac	6 to 5: range planting, prescribed grazing	**5. Seeded Rangeland** 5.1 Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 1800 lbs/ac

Figure 10. State and Transition Model MLRA 77E Sandy Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 10) was derived from functional group production for the reference communities in the ecological site descriptions that were correlated to this ecological site class. The Sandy Upland ecological site class reference state produces mixed tallgrass, midgrass and shrub species including sand bluestem, little bluestem, giant sandreed, queen's delight, grassland blazingstar, sand sagebrush, and skunkbush sumac with 10-15% bare ground. With no regular fire and/or continuous heavy grazing, the site is likely to transition to an herbaceous - woody state (2.1) with an increase in little bluestem, sand sagebrush, and skunkbush sumac. With chemical brush management, fire, and/or light grazing with regular growing season deferment it may return to the reference conditions (1.1). However, with more time and continued conditions, it will likely transition to a shrub dominated state (3.1). This will entail the inclusion of sand dropseed and an increase of bare ground to 25%. If the site is treated with chemical brush management and range seeding and/or rest followed by light grazing during the regular growing season deferment, it may turn to a treated grassland state (2.1) with a return of grass species to representative values, but shrubs still at an increased amount from reference conditions. If the land is converted to cropland (4), it can move into the seeded rangeland state (5.1) directly or with range planting following abandonment. Prescribed grazing will be required to help ensure establishment and to maintain the plant community.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 7. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM.

Table 7. NRI Community Class Data and RHEM Results - MLRA 77E Sandy Upland Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.7.1.1	Summer Midgrass, Summer Shortgrass, Summer Perennial Forb, Summer Tallgrass, Summer Rhizomatous Grass, Summer Annual Forb, Evergreen Shrub	blue grama (BOGR2)(495), little bluestem (SCSC)(349), silver bluestem (BOSA)(222), sideoats grama (BOCU)(213), sand dropseed (SPCR)(96), giant dropseed (SPGI)(93), beeblossom (OECI)(90)	2415	0.42	8.84	21
077E.7.2.1	Summer Midgrass, Summer Shortgrass, Spring Annual Forb(I), Monocot Shrub, Evergreen Shrub, Summer Rhizomatous Grass, Spring Perennial Forb	little bluestem (SCSC)(195), blue grama (BOGR2)(183), Russian thistle (SALSO)(183), sand sagebrush (ARFI2)(126), Yucca spp. (YUCCA)(124), sideoats grama (BOCU)(77), plains bristlegrass (SEVU2)(76)	1980	0.20	6.90	16
077E.7.3.1	Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb	honey mesquite (PRGL2)(507), Yucca spp. (YUCCA)(468), sand dropseed (SPCR)(352), sand sagebrush (ARFI2)(284), Sporobolus spp. (SPORO)(271), Buffalograss (BODA2)(242), sideoats grama (BOCU)(242), blue grama (BOGR2)(242)	3223	0.18	7.30	3

Supporting Information

The following publications support the State and Transition Model (STM). The first publication found that with moderate grazing there was no significant change in herbage production. This concurs with the STM, which suggests heavy, season-long grazing would cause a significant change. The second publication suggested that overall herbage production will not change with grazing versus non-grazing, but there will be an alteration of species composition with the notable increase in little bluestem and sand bluestem with grazing.

Gillen, R. L., and P.L. Sims. 2004. Stocking rate, precipitation, and herbage production on sand sagebrush-grassland. Journal of Range Management 57(2): 148-152.

Data from this study was gathered from the last four years of a 20-year research project. The study was located in northwestern Oklahoma at the Southern Plains Experimental Range. The landscape was gently rolling, stabilized sand dunes with vegetation dominated by sand sagebrush with an average canopy cover of 38%. The herbaceous understory was comprised of a sand sagebrush-bluestem prairie. Three stocking rates with continuous grazing were initiated in 1941 with two replications. For a ten-year period, the average stocking rate treatments were 43, 57, and 85 animal-unit-days (AUD)/ha. The stocking rates were set with the goal of approximately 2/3 of the herbage being utilized by the end of the dormant season. This allowed for 25-mm stubble for the shortgrasses and 100-mm stubble for the tallgrasses. Herbage was sampled by taking standing crop estimates of exclosures in all treatment pastures. Four quadrats were estimated in each exclosure, with a total of twenty exclosures in each pasture. Each exclosure was moved on a yearly basis. Grasses estimated individually included sand bluestem, little bluestem, sand lovegrass, sand paspalum, fall witchgrass, sand dropseed, and blue grama. Herbage production data was analyzed as a completely randomized design using analysis-of-variance with repeated measures. Stocking rate was the main plot factor and year was the repeated factor. During the years of data collection precipitation was in a favorable period after recovering from a major drought.

The results showed a total annual production from herbaceous species was 1,490 kg/ha when averaged over stocking rates and years. Grasses comprised 89% of the herbaceous standing crop and forbs consisted of 11%. Blue grama, sand lovegrass, sand paspalum were the three most productive grasses. After 17 to 20 years of treatment, stocking rate had little impact on the herbaceous production or the relative composition. The one exception in the relative composition was seen with an increase of sand dropseed. Production and relative composition varied over years for all species when evaluating year effects. For production, the only exception was blue grama. Relative composition showed exceptions with sand bluestem and sand paspalum. Little bluestem and sand lovegrass had the largest changes during the study. Production increased by factors of 6 for little bluestem and 10 for sand lovegrass, with relative composition having large positive responses over the time. Production of sand dropseed and blue grama showed little response over time, however, the relative composition decreased. The results of this study concluded that over the 20 years there was little effect on herbaceous production by differential stocking rates. This was a varying finding from previous studies on sandy rangeland in the western Great Plains which reported reductions in herbaceous production with an increase in stocking rate. It found that herbaceous production was more responsive to weather than to stocking rate.

Berg, W.A., J.A. Bradford, and P.L. Sims. 1997. Long-term soil nitrogen and vegetation change on sandhill rangeland. Journal of Range Management 50(5): 482-486.

The primary objective of this study was to determine nitrogen (N) in soil, vegetation, and litter in grazed Southern Great Plains sandhills rangeland as compared to adjacent areas where cattle grazing was excluded for 50 years. The sand sagebrush in the Simms area had been controlled with 2, 4-D herbicide. The site had been "observed to be in extremely poor condition as a result of severe drought, intense heat and close grazing". The vegetation was considered sand sagebrush-bluestem prairie type with the topography of rolling hills and no well-defined drainage patterns. In 1941, experimental pastures and associated livestock exclosures were fenced prior to beginning rotational grazing and cattle stocking studies. Sand sagebrush had been nearly eliminated on some portions of the experimental pastures by herbicide. E Eight sites were selected for this study with the characteristics of: 1) Pratt loamy sand soils, 2) devoid or nearly devoid of sand sagebrush, 3) on uniform topography within a sampling area of 20 by 100m within the exclosure and a paired area in the adjacent pasture. The eight pastures were grazed moderately with 0.29 yearling steer/ha/year. It was grazed under moderate stocking with year-long grazing which left approximately 1/3 of the average production of forage at the end of the grazing period. From 1942 to 1961, six pastures were grazed under moderate stocking and two under heavy stocking. Cattle were supplemented in the winter. Soil samples were taken throughout the course of the study. Pasture sampling areas were fenced to exclude livestock in 1993. Vegetation and litter were sampled randomly during this time. Frequency of species rooted within a quadrat was recorded and herbage clipped by species or class.

Results indicated that grazing had no significant effect on carbon and nitrogen concentrations. When calculated on a content basis, grazing had significant effect on C and N in the surface 2 inches of the soil. This suggests further studies are encouraged to have increased attention to sampling depth. Consistent sampling of adjacent pastures showed vegetation contrast induced by moderate as compared to heavy grazing. Total herbage production and total herbage N uptake were not significantly different between grazed pastures and non-grazed exclosures. Among species there were many significant differences between the grazed and un-grazed pastures in herbage production, N uptake, and frequency. The removal of sand sagebrush with herbicide altered the vegetation structure and may have impacted the C and N dynamics as well. Total grass production averaged 1,280 kg/ha in the grazed pastures is comparable to the 1,200kg/ha measured in previous years. In comparing species, blue grama and sand dropseed produced more herbage, accounted for greater N uptake, and had greater frequency in grazed areas. In non-grazed areas, little bluestem and sand bluestem produced more herbage, had greater N uptake, and greater frequency. Although Texas bluegrass had significantly higher frequency in the non-grazed area, its herbage production and N uptake was significantly higher in the grazed area. Perennial forb production was 3-fold higher in the grazed than in the non-grazed. Considering litter, non-grazed areas contained more than twice as much as grazed areas. This study concluded that fifty years of livestock exclusion had no measureable effect on C and N concentration in the surface2 inches of soil, total herbage production, or total plant uptake of N, as compared to adjacent moderately grazed rangeland. However, litter and total N in litter were greater in non-grazed pastures. There were substantial differences in frequency and herbage production among plant species when comparing grazed and non-grazed conditions. Little bluestem was a major producer in non-grazed areas. Western ragweed, blue grama, and sand dropseed were common in grazed areas. This data was concluded to indicate that plant species are both a cause and an effect of patterns of nutrient cycling. The species responses to grazing appeared to be related to herbivore selectivity, grazing tolerance, and above-ground net primary production of the various species of vegetation. This study found that sand bluestem and little bluestem together accounted for 30 and 55 percent of the N uptake in grazed and non-grazed mixed grass prairie.

Additional Literature Pertinent to the STM

Simms, P.L. and R.L. Gillen. 1999. Rangeland and steer response to grazing in the Southern Plains. Journal of Range Management 52(6): 651-660.

Gillen R.L. and P.L. Simms. 2006. Stocking rate and weather impacts on sand sagebrush and grasses: A 20-year record. Journal of Range Management 59(2): 145-152.

LIMY UPLAND ECOLOGICAL SITE CLASS

Figure 11. MLRA 77E Limy Upland ecological site class.

General Description

This ecological site class occurs in an upland position on hills and alluvial fans. It does not receive run-on moisture from adjacent sites. The soils are moderately deep to deep calcareous loams.

Geomorphic Features

Landscape Position:	Hills, Ridges, Alluvial Fans
Slope (percent):	3-15

Representative Soil Features

Soil Depth:	Moderately Deep to Deep
Parent Material Kind:	Alluvium, Colluvium
Parent Material Origin:	Limestone
Surface Texture:	Loam
Surface Texture Modifier:	None
Subsurface Texture Group:	Loamy
Drainage Class:	Well Drained
Permeability Class:	Moderate
Chemistry:	Calcareous throughout
Available Water Capacity:	2.5-6.5 inches

State and Transition Model

1.Perennial - Annual Herbaceous 1.1 Summer Shortgrass, Summer Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Stoloniferous Grass, Summer Rhizomatous Grass, Spring Midgrass 1622 lbs/ac	1 to 2: Continuous heavy grazing, lack of fire 2 to 1: chemical brush management, prescribed burning, prescribed grazing	**2. Herbaceous – Woody** 2.1 Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti 2071 lbs/ac
1 to 4: plow, disk, plant	2 to 4: plow, disk, plant 3 to 1: brush management, prescribed burning, range planting, prescribed grazing	2 to 3: continuous heavy grazing, lack of fire or brush management 3 to 2: chemical brush management, prescribed burning, range planting, prescribed grazing
4. Cultivated Cropland **Average County Yields** Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	3 to 4: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb 1384 lbs/ac
4 to 6: abandonment 6 to 4: plow, disk, plant	4 to 5: range planting, prescribed grazing 5 to 4: plow, disk, plant	
6. Abandoned Cropland 6.1 Annual Forb, Perennial Forb, Summer Shortgrass, Summer Midgrass 500 lbs/ac	6 to 5: range planting, prescribed grazing	**5. Seeded Rangeland** 5.1 Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 1400 lbs/ac

Figure 12. State and Transition Model MLRA 77E Limy Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 12) was derived from functional group production for the reference communities in the ecological site descriptions that were correlated to this ecological site class. The reference community for the Limy Upland Ecological site class produces an average of 1622 lbs/ac each year. This typically includes sideoats grama, little bluestem, blue grama, vine mesquite, purple threeawn, buffalograss, sand dropseed, western wheatgrass, broom snakeweed, and soapweed yucca. With continuous season long heavy grazing and no fire, it is likely to transition to an herbaceous - woody state. This state will show an increase in purple threeawn, sand dropseed, broom snakeweed, and soapweed yucca. A return to reference conditions from this state would require brush management, and light grazing with regular growing season deferment. However, further heavy continuous grazing, reduced fire, and brush increase will cause a shrub dominated state to result. To return to the previous state, a site will require brush management, range planting, prescribed grazing with regular growing season deferment, and prescribed fire.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 8. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM.

Table 8. NRI Community Class Data and RHEM Results - MLRA 77E Limy Upland Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.8.1.1	Summer Shortgrass, Summer Midgrass, Summer Perennial Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Annual Forb, Summer Stoloniferous Grass	blue grama (BOGR2)(509), sideoats grama (BOCU)(262), little bluestem (SCSC)(171), hairy grama (BOHI2)(103), Buffalograss (BODA2)(87), Cuman ragweed (AMPS)(39), Threeawn (ARIST)(37)	1699	0.31	12.40	33
077E.8.2.1	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti	blue grama (BOGR2)(669), Buffalograss (BODA2)(233), sideoats grama (BOCU)(206), Yucca spp. (YUCCA)(134), sand sagebrush (ARFI2)(87), prairie broomweed (AMDR)(75), hairy grama (BOHI2)(70)	2071	0.34	10.20	9
077E.8.3.1	Monocot Shrub, Spring Perennial Forb, Evergreen Shrub, Summer Midgrass, Summer Tallgrass, Deciduous Tree, Summer Shortgrass	soapweed yucca (YUGL)(329), hairy false goldenaster (HEVI4)(261), sand sagebrush (ARFI2)(188), tall dropseed (SPCO16)(139), Chickasaw plum (PRAN3)(96), sand dropseed (SPCR)(57), purple threeawn (ARPU9)(46)	1384	0.27	12.92	3

Supporting Information

The following publications support the State and Transition Model (STM). The first publication found that many of the desirable grass species will increase post-fire, and periodic burning appeared to have a place in the maintenance and management of this site class in MLRA 77E. The second publication showed similar results with the increase of several grass species post-fire.

Trlica, M.J. Jr., and J.L. Schuster. 1969. Effects of fire on grasses of the Texas high plains. Journal of Range Management 22(5): 329-333.

This study examined the effects of burning on the community and individual plants on a Deep Hardland ecological site in the Texas High Plains. The outcome of this study was purposed to assist in planning the use of burning as a range practice in this and similar environments. Vegetation at the experimental area was comprised of blue grama, sand dropseed, tumble windmillgrass, buffalograss, red threeawn, and tumblegrass. Climax species for this site include blue grama, buffalograss, western wheatgrass, and sideoats grama. During the summer of 1965, six adjacent 100 x 50 ft. plots were established. Fire buffers were created around each plot and the area fenced to exclude livestock. Ten 9.6 sq. ft. permanent quadrats were created along a transect through the center of each plot. Twenty-five individual plants per plot of four grass species were selected from each quadrat to study. Twenty-five blue grama, sand dropseed, red threeawn, and tumble windmillgrass plants were measured for basal area, number of seedstalks, and leaf length. Herbage yield for each treatment was determined at the end of the growing season. Each of the six plots received a burning treatment. Two plots were burned in the fall of 1965; one with and one against the wind, and two plots were burned in the spring of 1966 with the same conditions. One plot was burned with the wind in the summer of 1966. The remaining plot served as the control. The plots that were burned with the wind were burned a second time. Soil moisture conditions were determined gravimetrically and maximum temperatures during the burns were measured using a modification of the technique by Bently and Fenner (1958). Pyrometric crayon marks ranging from 125F to 1800F were placed on rectangular pieces of asbestos to form fusion pyrometers. These were placed at ground level within and between grass clumps.

The results found that the fusion pyrometers placed within the clumps of blue grama indicated that plots burned with the wind had the highest temperatures; with the highest recorded during the spring of 1966. There were no significant differences in soil moisture between plots at the time of the fall and spring burns. All burning reduced forage yields the first and second year post-fire. It was found that less damage occurs with summer fires versus fall or spring fires. Production of plots burned for two years consecutively was only slightly less forage than those only burned once. Successive fires do not appear to have a cumulative effect on total herbage yields. The average basal diameters of blue grama increased regardless of treatment. The basal diameters of red threeawn and sand dropseed decreased on the plots burned two years in succession, but maintained or increased in the unburned control and plots burned only once. Blue grama continued to increase in all treatments except when burned in the spring with wind for two successive years. The average basal diameter of tumble windmillgrass decreased 44% in all treatments. However, basal diameters of this plant species decreased 64% on the unburned plot and only 40% on the burned. Burning appeared to prevent natural decreases for tumble windmillgrass. The maximum height for red threeawn, blue grama, and sand dropseed decreased regardless of treatment, but burning reduced the heights of sand dropseed more than red threeawn or blue grama. There was recovery for blue grama in the second year when height growth became greater. Seedstalk production was lower for the three species in 1967 than 1965. Blue grama produced more seedstalks in 1966 than 1965 regardless of burning treatment. Conversely, burning significantly reduced seedstalk production of sand dropseed during the first and second growing seasons after fire. Fire had little effect on seedstalk growth with red threeawn the first growth season post-fire, but the second growing season showed greater growth the second year in all burned plots. Therefore, it appeared burning stimulated seedstalk growth with blue grama, but was detrimental to sand dropseed.

In conclusion, this study implicated that periodic burning appeared to have a place in the management of the Texas High Plains. The reduction in herbage yields may have been compensated by the favorable response of desired species such as blue grama. This study showed that burning would reduce the time required for the range to reach its productive potential by favoring the fire tolerant species.

ROCKY SLOPES ECOLOGICAL SITE CLASS

Figure 13. MLRA 77E Rocky Slopes ecological site class.

General Description

This ecological site class occurs in an upland position on gravelly and channery hills, ridges and alluvial fans. It does not receive run-on moisture from adjacent sites. This site class has deep, calcareous sandy loam to loam textured soils. As water erosion occurs on this site, the gravels in the soil profile are exposed, armoring the soil surface and protecting the site from further wind and water erosion. As with other site classes in this MLRA, the Rocky Slopes ecological site class is also used for cultivation.

Geomorphic Features

Landscape Position:	Hills, Ridges, Alluvial Fans
Slope (percent):	3-25

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Alluvium, Outwash
Parent Material Origin:	Mixed
Surface Texture:	Sandy Loam to Loam
Surface Texture Modifier:	Gravelly to Very Cobbly
Subsurface Texture Group:	Loamy
Drainage Class:	Well Drained to Excessively Drained
Permeability Class:	Moderate to Rapid
Chemistry:	Calcareous throughout
Available Water Capacity:	1-4 inches

State and Transition Model

1. Perennial - Annual Herbaceous 1.1 Summer Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Tallgrass, Summer Annual Forb, Summer Shortgrass, Spring Annual Forb 1636 lbs/ac	1 to 2: Continuous heavy grazing, lack of fire 2 to 1: chemical brush management, prescribed burning, prescribed grazing	**2. Herbaceous – Woody** 2.1 Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti 2071 lbs/ac
1 to 4: plow, disk, plant	2 to 4: plow, disk, plant 3 to 1: brush management, prescribed burning, range planting, prescribed grazing	2 to 3: continuous heavy grazing, lack of fire or brush management 3 to 2: 3-5 year growing season deferment, chemical brush management, prescribed burning, range planting, prescribed grazing
4. Cultivated Cropland **Average County Yields** Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	3 to 4: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb 1384 lbs/ac
4 to 6: abandonment 6 to 4: plow, disk, plant	4 to 5: range planting, prescribed grazing 5 to 4: plow, disk, plant	
6. Abandoned Cropland 6.1 Annual Forb, Perennial Forb, Summer Shortgrass, Summer Midgrass 500 lbs/ac	6 to 5: range planting, prescribed grazing	**5. Seeded Rangeland** 5.1 Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 750 lbs/ac

Figure 14. State and Transition Model MLRA 77E Rocky Slopes ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 14) was derived from functional group production for the reference communities in the ecological site descriptions that were correlated to this ecological site class. The reference community produces approximately 1635 lbs/acre. This herbaceous dominated state (2.1) is composed of little bluestem, sideoats grama, blue grama, hairy grama, sand dropseed, purple threeawn, New Mexico feathergrass, big bluestem, and Indiangrass. With heavy continuous grazing and a lack of fire, the vegetation is expected to transition to an herbaceous - woody state (3.1) with a reduction in little bluestem, sideoats grama, and New Mexico feathergrass. Increases will be evident in purple threeawn, blue grama, and hairy grama. It is likely the site will also begin to have a presence of broom snakeweed, sand sagebrush, plains pricklypear, and soapweed yucca. The site has the potential to return to reference conditions (1.1) via moderate grazing with regular season deferment, fire, or chemical brush management. However, with no management action, the site is likely to progress to a shrub dominated state. The shrub state (3.1) will show an increase in broom snakeweed, plains pricklypear, soapweed yucca, sand sagebrush and the appearance of oneseed juniper. To return to the previous state (2.1), it will require 3-5 years of growing season deferment followed by moderate grazing, chemical/mechanical brush management and range planting. If the land is converted to cropland (4), it can move into the seeded rangeland state (5.1) directly or following abandonment by applying range planting or critical area planting. Prescribed grazing will be required to help ensure establishment and to maintain the plant community.

NRI Primary Sampling Units (PSUs) were correlated to these community classes were possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 9. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM.

Table 9. NRI Community Class Data and RHEM Results - MLRA 77E Rocky Slopes Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
077E.9.1.1	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Annual Forb, Spring Perennial Forb, Summer Tallgrass	blue grama (BOGR2)(418), Buffalograss (BODA2)(280), sideoats grama (BOCU)(215), Cuman ragweed (AMPS)(193), little bluestem (SCSC)(171), hairy grama (BOHI2)(114), ragweed (AMBRO)(77)	2195	0.21	8.03	38
077E.9.2.1	Summer Midgrass, Summer Shortgrass, Monocot Shrub, Summer Perennial Forb, Cacti, Spring Perennial Forb, Evergreen Subshrub	little bluestem (SCSC)(595), sideoats grama (BOCU)(227), Yucca spp. (YUCCA)(130), hairy grama (BOHI2)(113), blue grama (BOGR2)(107), Opuntia spp. (OPUNT)(95), Cuman ragweed (AMPS)(88)	2040	0.23	8.71	18
077E.9.3.1	Monocot Shrub, Summer Midgrass, Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Perennial Forb, Spring Annual Forb(I)	Yucca spp. (YUCCA)(511), blue grama (BOGR2)(247), woolly paperflower (PSTA)(181), sideoats grama (BOCU)(165), Cuman ragweed (AMPS)(135), sand dropseed (SPCR)(130), trailing krameria (KRLA)(111)	2750	0.16	8.63	7

Supporting Information

The following publications support the State and Transition Model (STM). The first publication found that with complete control of yucca, soil water content increases and allows for desirable grass species to thrive without competition. The second publication examined grazing impacts and found similar increasers and decreasers as the STM.

Sosebee, R.E., F.M. Churchill, and C.W. Green. 1982. Soil water depletion by yucca. Journal of Range Management 35(6): 774-776.

This study in the years of 1971 through 1975, was aimed at evaluated the influence of yucca on soil water depletion and herbage response. It took place on an Edward's Plateau outcropping within the Rolling Plains of Texas on a Mixland range site. Herbaceous vegetation consisted of sideoats grama, hairy grama, blue grama, silver bluestem, perennial threeawns, sand dropseed, buffalograss, hooded windmillgrass, Reverchon's bristlegrass, and Texas croton. Following control of ash and redberry juniper, yucca invaded the area and became the dominant noxious species with a density of approximately 5000 plants/ha.

The study was designed as randomized blocks with three treatments and three blocks of 30 x 30m with 4.6m buffers. The treatments were set up as no yucca, approximately 2500 yucca plants/ha, and approximately 5000 plants/ha. Plants were removed via hand-grubbing. Soil and water content was measured weekly from June through August and monthly from September through May each year. Soil cores were collected and soil samples oven-dried. Precipitation was measured and herbage yields represented by five random quadrats/treatment/block.

The results determined that soil water content was much higher where yucca had been removed. Treated sites had a soil water content of 5.4% in July to 15.4% in October. This was compared to the 2500 plants/ha and 5000 plants/ha that July lows of 4.8% and 4.7% and October highs of 14.3% and 14.0%. Herbage production was related to yucca control and soil water depletion. The complete removal of yucca caused an increased grass yield. This was also closely related to the amount of precipitation. However, even during "wet years" grass production was reduced from the increased competition of yucca.Conclusions of the study found that yucca must be controlled in order to increase water storage. Additionally, to increase desirable herbaceous plants, complete removal or control of yucca is necessary to increase water storage in the rooting zone of these plants. Partial control or thinning has little effect on increasing soil water content. Therefore, complete control of yucca allows herbage yields to increase when adequate precipitation occurs as competition is not an issue.

Gillen, R.L. and W.A. Berg. 2001. Complementary grazing of native pasture and old world bluestem. Journal of Range Management 54(4): 348-355.

The objective of this study was to compare steer production systems based on native pasture or combination of native pasture and Old World bluestem pastures. There was specific interest on the impact of native pasture and on livestock production, the performance of 2 cultivars of Old World bluestem, and the relative net returns from 2 systems.

The study was conducted from 1993 to 1997 at the Southern Plains Range Research Station in northwestern Oklahoma. Two major types of pastures were used in the study. The first consisted of a native sand sagebrush-mixed prairie on sandy, mixed thermic soils. The second pasture was a monoculture of the introduced grass Old World bluestem. These pastures were burned each spring to remove dead standing forage. For the study, the grazing season was divided into 4 periods. Average dates of these systems were: 1) winter, 21 December to 15 March, 2) Early Native, 15 March to 9 June, 3) Old World Bluestem, 9 June to 30 July, and 4) Late Native, 30 July to 31 August. Stocking rates were based on a moderate stocking rate. Gain and value of the steers was assessed throughout the study.

It was found that production system had no impact on the frequency of any plant species. Species that did not change in frequency throughout the years included sand bluestem, switchgrass, little bluestem, sand lovegrass, sand paspalum, and purple threeawn. All of these species would be considered palatable decreasers. Perennial threeawn increased moderately as stocking rates were reduced. Sideoats grama, sand dropseed, fall witchgrass, sand sedge, windmillgrass, blue grama, sandbur, and sand sagebrush all increased over the years, regardless of treatment. Species that decreased over the years included Texas bluegrass, Scribner's dicanthelium, western ragweed, annual buckwheat, camphorweed, and plantago. Drought may have contributed to some of these decreasers.

Additional Literature Pertinent to the STM

Coppedge, B.R. and J.H. Shaw. Bison grazing patterns on seasonally burned tallgrass prairie. Journal of Range Management 51(3): 258-264.

Harrell, W.C. and S.D. Fuhlendorf. 2002. Evaluation of habitat measures in a shrubland community. Journal of Range Management 55(5): 488-493.

WET BOTTOMLAND ECOLOGICAL SITE CLASS

Figure 15. Wet Bottomland ecological site class.

General Description

The Wet Bottomland ecological site class occurs in the lowest portions of the landscape. This site receives run-on and/or subsurface water flows from adjacent uplands. It has a shallow water table available for plant growth at least seasonally in most years. Surface water may be present all or part of the year. Wetland soils and obligate wetland vegetation may be present. Flooding and/or ponding occurs occasionally to frequently. Potential plant community production is significantly higher than that of adjacent uplands, and the response to management is more rapid because of the availability of water. This ecological site class has the highest wildlife diversity.

Geomorphic Features

Landscape Position:	Floodplains
Slope (percent):	0-2 percent

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Mixed
Parent Material Origin:	Mixed
Surface Texture:	Loam; Fine Sandy Loam
Surface Texture Modifier:	None
Subsurface Texture Group:	Loamy
Drainage Class:	Poorly Drained
Permeability Class:	Slow to Moderate
Chemistry:	None
Available Water Capacity:	3-5 inches

State and Transition Model

1. Perennial - Annual Herbaceous		2. Herbaceous – Woody
1.1 Summer Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Tallgrass, Summer Annual Forb, Summer Shortgrass, Spring Annual Forb 5500 lbs/ac	1 to 2: Continuous heavy grazing, lack of fire 2 to 1: brush management, prescribed burning, prescribed grazing	2.1 Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti 3000 lbs/ac

Figure 16. State and Transition Model, MLRA 77E, Wet Bottomland ecological site class.

Vegetation Dynamics

The proposed States and Community Classes are derived from the State and Transition model in the MLRA 77E Wet Bottomland 16-24" PZ ecological site description. According to the ecological site description state and transition model, the reference conditions of this ecological site class would produce approximate 5500 lbs/ac of aboveground vegetation each year on a dry weight basis. This would consist mainly of tallgrasses including switchgrass, Indiangrass, prairie cordgrass, sand bluestem, Eastern gamagrass, little bluestem, sideoats grama, western wheatgrass with sedge, hackberry, and Eastern cottonwood. With heavy continuous grazing and no fire, the site would likely transition to an herbaceous-woody state (2.1).

Return to reference conditions (1.1) would require planned grazing that allows for periodic growing season rest, and mechanical or chemical brush management and prescribed burning. With heavy continuous grazing, the site would likely turn to an herbaceous-woody state (2.1) with a production decrease to a 3000 lbs/ac and no return to reference conditions. The plant community would consist of bermudagrass, Missouri goldenrod, Baldwin's ironweed, willow baccharis, and Russian olive.

There are no NRI Primary Sampling Units correlated to this ecological site class.

Table 9. NRI Community Class Data and RHEM Results - MLRA 77E Wet Bottomland Ecological Site Class

Comm Class ID	Community Class	Dominant Species (Symbol, Lbs/Ac)	Lbs/Ac	Soil Loss T/Ac/Yr	% Runoff	# PSUs
077E.22.1.1	Summer Tallgrass, Summer Perennial Forb, Spring Midgrass, Summer Annual Forb, Spring Perennial Grasslike, Spring Rhizomatous Grass, Deciduous Shrub	blue grama (BOGR2)(418), Buffalograss (BODA2)(280), sideoats grama (BOCU)(215), Cuman ragweed (AMPS)(193), little bluestem (SCSC)(171), hairy grama (BOHI2)(114), ragweed (AMBRO)(77)	5500	N/A	N/A	0

Supporting Information

The following publication supports the State and Transition Model. It evaluates the performance of the ALMANAC model. ALMANAC used a series of variables to simulate what ecological conditions would persist on varying ecological sites. The conclusions of the study matched USDA NRCS expectations.

Kiniry, J.R., H. Sanchez, J. Greenwade, E. Seidensticker, J.R. Bell, F. Pringle, G. Peacock, Jr., and J. Rives. 2002. Simulating grass productivity on diverse range sites in Texas. Journal of Soil and Water Conservation 57(3):144-150.

The purpose of this study was to demonstrate the capability of ALMANAC to dynamically simulate annual productivity of grasses in five regions of Texas. Ecological sites for this study were chosen to represent the varying rainfall zones in Southern High Plains of Texas. Range site yields from USDA NRCS county soil surveys were matched to simulated annual production and given the values of "favorable", "normal", and "unfavorable". Sampling was done for approximately three years at the end of each growing season at 10 randomly selected plots at each site. The vegetation was clipped, dried, and weighed and above-ground biomass measured. Annual production was simulated using the most common reported grass species, prevalent soil series, and 60 years of generated climate data. The ALMANAC model simulates water and nutrient balances and interception of solar radiation, which then creates plant growth with leaf area index (LAI), light interception, and radiation use efficiency (RUE). RUE simulates the biomass growth. It also models stress such as drought, nutrient deficiency, and temperature extremes. In the Texas High Plains, "very shallow", "deep hardland", "sand hills", "sandy loam", "mixed slopes", "loamy bottomland", and "wet bottomland" ecological sites were simulated.

The results found that for average years, ALMANAC simulations were realistic at nearly all of the ecological sites. The six highest yielding sites were the Blackland and Clay Loam sites in central Texas, the Wet Bottomland site in the High Plains, the Claypan prairie in northeast Texas, and the two sites on the Gulf Coast. Similarly, the results for favorable rain years were comparable to the NRCS yields for favorable years. The largest gap from NRCS data was during the unfavorable years. In conclusion, the ALMANAC model came to similar findings as the USDA NRCS ecological site characteristics. The model is expected to accurately simulate vegetation characteristics that vary by soil type, depth, temperature, rainfall, and vegetation cover.

APPENDIX A. MLRA 77E, ECOLOGICAL SITE CLASSES SHOWING THE ECOLOGICAL SITES, ECOLOGICAL SITE IDS, AND PLANT COMMUNITY CLASSES THAT WERE CORRELATED TO EACH SITE CLASS.

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Bottom**	Draw 16-24" PZ	R077EY052TX
		Loamy Bottomland 16-24" PZ	R077EY058TX
		Sandy Bottomland 16-24" PZ	R077EY065TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Tallgrass, Summer Perennial Forb, Summer Midgrass, Summer Annual Grass, Summer Shortgrass, Summer Annual Forb, Spring Perennial Forb	077E.2.1.1
		Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Perennial Forb, Spring Annual Forb, Summer Annual Forb	077E.2.2.1
		Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass	077E.2.3.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Breaks**	Breaks 16-24" PZ	R077EY062TX
		Very Shallow 16-24" PZ	R077EY068TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Tallgrass, Spring Perennial Forb, Monocot Shrub	077E.12.1.1
		Deciduous Shrub, Evergreen Subshrub, Spring Perennial Forb, Monocot Shrub, Summer Midgrass, Spring Annual Forb, Evergreen Tree	077E.12.2.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Clayey Upland**	Clay Loam 16-24" PZ	R077EY051TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Summer Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb, Summer Annual Forb	077E.4.1.1
		Spring Annual Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Midgrass, Spring Rhizomatous Grass, Summer Perennial Forb, Summer Shortgrass	077E.4.2.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Limy Upland**	Hardland Slopes 16-24" PZ	R077EY055TX
		Limy Upland 16-24" PZ	R077EY057TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Summer Midgrass, Summer Perennial Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Annual Forb, Summer Stoloniferous Grass	077E.8.1.1
		Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti	077E.8.2.1
		Monocot Shrub, Spring Perennial Forb, Evergreen Shrub, Summer Midgrass, Summer Tallgrass, Deciduous Tree, Summer Shortgrass	077E.8.3.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Rocky Slopes**	Gravelly 16-24" PZ	R077EY053TX
		Mixedland Slopes 16-24" PZ	R077EY061TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Annual Forb, Spring Perennial Forb, Summer Tallgrass	077E.9.1.1
		Summer Midgrass, Summer Shortgrass, Monocot Shrub, Summer Perennial Forb, Cacti, Spring Perennial Forb, Evergreen Subshrub	077E.9.2.1
		Monocot Shrub, Summer Midgrass, Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Perennial Forb, Spring Annual Forb(I)	077E.9.3.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Sandy Upland**	Sandy 16-24" PZ	R077EY064TX
		Sandy Loam 16-24" PZ	R077EY066TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Midgrass, Summer Shortgrass, Summer Perennial Forb, Summer Tallgrass, Summer Rhizomatous Grass, Summer Annual Forb, Evergreen Shrub	077E.7.1.1
		Summer Midgrass, Summer Shortgrass, Spring Annual Forb(I), Monocot Shrub, Evergreen Shrub, Summer Rhizomatous Grass, Spring Perennial Forb	077E.7.2.1
		Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb	077E.7.3.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
77E	**Wet Bottomland**	Wet Bottomland 16-24" PZ	R077EY571TX
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Tallgrass, Summer Perennial Forb, Spring Midgrass, Summer Annual Forb, Spring Perennial Grasslike, Spring Rhizomatous Grass, Deciduous Shrub	077E.22.1.1

APPENDIX B. MLRA 77E, ECOLOGICAL SITE CLASS AND COMMUNITY CLASS SUMMARY

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
Bottom	Perennial - Annual Herbaceous	077E.2.1.1	Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Perennial Forb, Summer Annual Forb	2864	Summer Tallgrass (259), Summer Perennial Forb (160), Summer Midgrass (150), Summer Annual Grass (83), Summer Shortgrass (80), Summer Annual Forb (62), Spring Perennial Forb (45)	big bluestem (ANGE)(138), Cuman ragweed (AMPS)(134), Indiangrass (SORGH)(110), little bluestem (SCSC)(88), hairy grama (BOHI2)(80), Panicum spp (PANIC)(71), prairie broomweed (AMDR)(46)	1018
Bottom	Herbaceous - Woody	077E.2.2.1	Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Perennial Forb, Spring Annual Forb, Summer Annual Forb	3000	Summer Midgrass (740), Summer Rhizomatous Grass (546), Spring Rhizomatous Grass (470), Spring Annual Forb(I) (312), Summer Perennial Forb (188), Spring Annual Forb (181), Summer Annual Forb (130)	Buffalograss (BODA2)(543), sideoats grama (BOCU)(491), western wheatgrass (PASM)(469), kochia (BASC5)(300), Cuman ragweed (AMPS)(154), Canadian horseweed (COCA5)(130), alkali sacaton (SPAI)(110)	3006
Bottom	Woody - Herbaceous	077E.2.3.1	Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass	4445	Deciduous Shrub (2982), Spring Midgrass (475), Deciduous Tree (450), Spring Perennial Forb (226), Summer Rhizomatous Grass (113), Summer Perennial Forb (101), Spring Rhizomatous Grass (95)	golden currant (RIAU)(1638), Prunus spp. (PRUNU)(1344), Canada wildrye (ELCA4)(475), wingleaf soapberry (SASA4)(450), goldenrod (SOLID)(224), Buffalograss (BODA2)(105), Cuman ragweed (AMPS)(101)	4443
Bottom	Cultivated Cropland	077E.2.4.1	Wheat 20-30 bu/ac Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac				
Bottom	Seeded Rangeland	077E.2.5.1	Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	2000			

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
Breaks	Herbaceous - Woody	077E.12.1.1	Summer Midgrass, Summer Perennial Forb, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Summer Tallgrass, Deciduous Shrub	910	Summer Midgrass (667), Summer Shortgrass (418), Summer Rhizomatous Grass (353), Summer Perennial Forb (114), Summer Tallgrass (94), Spring Perennial Forb (66), Monocot Shrub (61)	Buffalograss (BODA2)(348), little bluestem (SCSC)(281), blue grama (BOGR2)(232), hairy grama (BOHI2)(179), sideoats grama (BOCU)(165), big bluestem (ANGE)(73), Threeawn (ARIST)(53)	2009
Breaks	Woody - Herbaceous	077E.12.2.1	Deciduous Shrub, Evergreen Subshrub, Spring Perennial Forb, Monocot Shrub, Summer Midgrass, Spring Annual Forb, Evergreen Tree	2333	Deciduous Shrub (423), Evergreen Subshrub (366), Spring Perennial Forb (308), Monocot Shrub (229), Summer Midgrass (218), Spring Annual Forb (211), Evergreen Tree (189)	shinnery oak (QUHA3)(380), Yucca spp. (YUCCA)(228), Rocky Mountain zinnia (ZIGR)(214), redberry juniper (JUCO11)(189), stemmy four-nerve daisy (TESC2)(142), lambsquarters (CHAL7)(136), trailing krameria (KRLA)(104)	2333
Clayey Upland	Perennial - Annual Herbaceous	077E.4.1.1	Summer Shortgrass, Summer Stoloniferous Grass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Summer Perennial Forb, Spring Perennial Forb	1510	Summer Shortgrass (578), Summer Perennial Forb (402), Summer Midgrass (319), Summer Rhizomatous Grass (296), Spring Perennial Forb (106), Spring Annual Forb (66), Summer Annual Forb (51)	blue grama (BOGR2)(555), Cuman ragweed (AMPS)(327), Buffalograss (BODA2)(296), silver bluestem (BOSA)(178), sand dropseed (SPCR)(78), woolly plantain (PLPA2)(58), annual buckwheat (ERAN4)(37)	1831
Clayey Upland	Herbaceous - Woody	077E.4.2.1	Spring Annual Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Midgrass, Spring Rhizomatous Grass, Summer Perennial Forb, Summer Shortgrass	1550	Spring Annual Forb (505), Summer Rhizomatous Grass (261), Spring Perennial Forb (158), Summer Midgrass (144), Spring Rhizomatous Grass (100), Summer Perennial Forb (91), Summer Shortgrass (73)	American star-thistle (CEAM2)(348), Buffalograss (BODA2)(186), Texas croton (CRTE4)(144), sideoats grama (BOCU)(112), purple monkeyflower (MILE2)(104), western wheatgrass (PASM)(99), vine mesquite (PAOB)(75)	1550
Clayey Upland	Woody - Herbaceous	077E.4.3.1	PRGLG (75 – 150), YUCCA (75 – 150), AAGG (75 – 150), AAFF (75 – 150), ARIST (50 – 75), BOSA (50 – 75), BOGR2 – 25 – 50, BODA2 – 25 – 50	900			
Clayey Upland	Cultivated Cropland	077E.4.4.1	Wheat 20-30 bu/ac. Corn 180 bu/ac				

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
			Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac				
Clayey Upland	Seeded Rangeland	077E.4.5.1	Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	1250			
Sandy Upland	Perennial - Annual Herbaceous	077E.7.1.1	Summer Perennial Forb, Summer Midgrass, Summer Tallgrass, Spring Perennial Forb, Spring Midgrass, Summer Annual Forb, Summer Rhizomatous Grass	2048	Summer Midgrass (1055), Summer Shortgrass (533), Summer Perennial Forb (211), Summer Tallgrass (177), Summer Rhizomatous Grass (112), Summer Annual Forb (75), Evergreen Shrub (65)	blue grama (BOGR2)(495), little bluestem (SCSC)(349), silver bluestem (BOSA)(222), sideoats grama (BOCU)(213), sand dropseed (SPCR)(96), giant dropseed (SPGI)(93), beeblossom (OECI)(90)	2415
Sandy Upland	Herbaceous - Woody	077E.7.2.1	Summer Midgrass, Summer Shortgrass, Spring Annual Forb(I), Monocot Shrub, Evergreen Shrub, Summer Rhizomatous Grass, Spring Perennial Forb	1980	Summer Midgrass (528), Spring Annual Forb(I) (280), Summer Shortgrass (230), Monocot Shrub (134), Evergreen Shrub (119), Summer Perennial Forb (100), Summer Rhizomatous Grass (93)	Russian thistle (SALSO)(280), blue grama (BOGR2)(176), little bluestem (SCSC)(174), Yucca spp. (YUCCA)(119), sand sagebrush (ARFI2)(118), sideoats grama (BOCU)(72), plains bristlegrass (SEVU2)(68)	1960
Sandy Upland	Woody - Herbaceous	077E.7.3.1	Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb	3223	Summer Midgrass (953), Deciduous Tree (509), Monocot Shrub (468), Summer Shortgrass (434), Evergreen Shrub (285), Summer Rhizomatous Grass (243), Summer Perennial Forb (111)	honey mesquite (PRGL2)(507), Yucca spp. (YUCCA)(468), sand dropseed (SPCR)(352), sand sagebrush (ARFI2)(284), Sporobolus spp. (SPORO)(271), blue grama (BOGR2)(242), sideoats grama (BOCU)(242), Buffalograss (BODA2)(242)	3223
Sandy Upland	Cultivated Cropland	077E.7.4.1	Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac			Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac	

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
Sandy Upland	Seeded Rangeland	077E.7.5.1	Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	1800			
Limy Upland	Perennial - Annual Herbaceous	077E.8.1.1	Summer Shortgrass, Summer Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Stoloniferous Grass, Summer Rhizomatous Grass, Spring Midgrass	1622	Summer Shortgrass (614), Summer Midgrass (586), Summer Perennial Forb (122), Summer Rhizomatous Grass (87), Spring Perennial Forb (59), Summer Annual Forb (36), Summer Stoloniferous Grass (25)	blue grama (BOGR2)(509), sideoats grama (BOCU)(262), little bluestem (SCSC)(171), hairy grama (BOHI2)(103), Buffalograss (BODA2)(87), Cuman ragweed (AMPS)(39), Threeawn (ARIST)(37)	1699
Limy Upland	Herbaceous - Woody	077E.8.2.1	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti	2071	Summer Shortgrass (741), Summer Midgrass (366), Summer Rhizomatous Grass (302), Monocot Shrub (134), Evergreen Shrub (118), Summer Annual Forb (99), Cacti (75)	blue grama (BOGR2)(669), Buffalograss (BODA2)(233), sideoats grama (BOCU)(206), Yucca spp. (YUCCA)(134), sand sagebrush (ARFI2)(87), prairie broomweed (AMDR)(75), hairy grama (BOHI2)(70)	2071
Limy Upland	Woody - Herbaceous	077E.8.3.1	Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb	1384	Monocot Shrub (333), Spring Perennial Forb (289), Evergreen Shrub (188), Summer Midgrass (163), Summer Tallgrass (139), Deciduous Tree (97), Summer Shortgrass (56)	soapweed yucca (YUGL)(329), hairy false goldenaster (HEVI4)(261), sand sagebrush (ARFI2)(188), tall dropseed (SPCO16)(139), Chickasaw plum (PRAN3)(96), sand dropseed (SPCR)(57), purple threeawn (ARPU9)(46)	1384
Limy Upland	Cultivated Cropland		Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac				
Limy Upland	Seeded Rangeland	077E.8.5.1	Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	1400			

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
Rocky Slopes	Perennial - Annual Herbaceous	077E.9.1.1	Summer Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Tallgrass, Summer Annual Forb, Summer Shortgrass, Spring Annual Forb	1636	Summer Shortgrass (541), Summer Midgrass (538), Summer Rhizomatous Grass (328), Summer Perennial Forb (277), Summer Annual Forb (157), Spring Perennial Forb (117), Summer Tallgrass (55)	blue grama (BOGR2)(418), Buffalograss (BODA2)(280), sideoats grama (BOCU)(215), Cuman ragweed (AMPS)(193), little bluestem (SCSC)(171), hairy grama (BOHI2)(114), ragweed (AMBRO)(77)	2195
Rocky Slopes	Herbaceous - Woody	077E.9.2.1	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti	2071	Summer Midgrass (986), Summer Shortgrass (253), Monocot Shrub (143), Summer Perennial Forb (131), Cacti (105), Spring Perennial Forb (98), Evergreen Subshrub (98)	little bluestem (SCSC)(595), sideoats grama (BOCU)(227), Yucca spp. (YUCCA)(130), hairy grama (BOHI2)(113), blue grama (BOGR2)(107), Opuntia spp. (OPUNT)(95), Cuman ragweed (AMPS)(88)	2039
Rocky Slopes	Woody - Herbaceous	077E.9.3.1	Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb	1384	Monocot Shrub (607), Summer Midgrass (536), Evergreen Subshrub (405), Summer Shortgrass (335), Spring Perennial Forb (155), Summer Perennial Forb (150), Spring Annual Forb(I) (101)	Yucca spp. (YUCCA)(511), blue grama (BOGR2)(247), woolly paperflower (PSTA)(181), sideoats grama (BOCU)(165), Cuman ragweed (AMPS)(135), sand dropseed (SPCR)(130), trailing krameria (KRLA)(111)	2752
Rocky Slopes	Cultivated Cropland	077E.9.4.1	Wheat 20-30 bu/ac. Corn 180 bu/ac Grain sorghum 20 bu/ac non-irrigated Grain sorghum 50 bu/ac irrigated Cotton 1.5 to 2 bales/ac				
Rocky Slopes	Seeded Rangeland	077E.9.5.1	Summer Midgrass, Summer Shortgrass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	750			
Wet Bottom-land	Perennial - Annual Herbaceous	077E.22.1.1	Summer Tallgrass, Summer Perennial Forb, Spring Midgrass, Summer Annual Forb, Spring Perennial Grasslike, Spring Rhizomatous	5500			

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD (Lbs/Ac)	NRI Comm Class (Lbs/Ac)	NRI Dominant Species (Symbol, Lbs/ac)	NRI (Lbs/Ac)
			Grass, Deciduous Shrub				
Wet Bottom-land	Herbaceous - Woody	077E.22.2.1	SCSC (50 – 100), PASM (100 – 200), CAREX (200 – 300), CYDA (500 – 1000), SOMI2(100 – 300), VEBA (100 – 300), BASA (500 – 1000), ELAN (100 – 200), PODE3(50 – 100)	3000			

Appendix C. MLRA 77E, NRI Cover and Erosion Data by Community Class

		|---------- Percent Cover Values ----------|									Avg	Avg	RHEM	RHEM	
Site Class Name	Comm Class ID	Bunch-grass	Sodgrass	Shrub	Forb + AnnGrass	Lichen	BareGrnd	Rock	Litter	Basal	Plant Ht (ft)	Prod (#/ac)	Soil Loss (T/Ac/Yr)	Runoff (%)	# PSUs
Breaks	077E.12.1.1	43	15	10	15	8	18	13	65	31	1.9	2009	0.35	13.77	21
	Summer Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Tallgrass, Spring Perennial Forb, Monocot Shrub														
Breaks	077E.12.2.1	40	2	37	16	7	4	14	71	10	2.3	2333	0.3	16.47	3
	Deciduous Shrub, Evergreen Subshrub, Spring Perennial Forb, Monocot Shrub, Summer Midgrass, Spring Annual Forb, Evergreen Tree														
Bottom	077E.2.1.1	39	21	19	12	0	12	1	63	36	1.4	1018	0.04	5.76	3
	Summer Tallgrass, Summer Perennial Forb, Summer Midgrass, Summer Annual Grass, Summer Shortgrass, Summer Annual Forb, Spring Perennial Forb														
Bottom	077E.2.2.1	27	23	14	29	0	15	13	55	31	2	3006	0.08	7.41	9
	Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Perennial Forb, Spring Annual Forb, Summer Annual Forb														
Bottom	077E.2.3.1	2	34	37	14	0	10	0	83	8	8.7	4443	0.03	7.68	2
	Deciduous Shrub, Spring Midgrass, Deciduous Tree, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Rhizomatous Grass														
Clayey Upland	077E.4.1.1	30	3	3	27	0	21	0	63	37	1.3	1831	0.38	12.46	4
	Summer Shortgrass, Summer Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb, Summer Annual Forb														
Clayey Upland	077E.4.2.1	7	30	16	35	44	1	4	42	34	1.6	1550	0.06	10.12	2
	Spring Annual Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Midgrass, Spring Rhizomatous Grass, Summer Perennial Forb, Summer Shortgrass														
Sandy Upland	077E.7.1.1	39	5	14	11	2	25	3	68	8	1.7	2415	0.42	8.84	21
	Summer Midgrass, Summer Shortgrass, Summer Perennial Forb, Summer Tallgrass, Summer Rhizomatous Grass, Summer Annual Forb, Evergreen Shrub														
Sandy Upland	077E.7.2.1	31	10	17	22	9	13	13	68	19	2	1960	0.2	6.9	18
	Summer Midgrass, Spring Annual Forb(I), Summer Shortgrass, Monocot Shrub, Evergreen Shrub, Summer Perennial Forb, Summer Rhizomatous Grass														
Sandy Upland	077E.7.3.1	26	2	13	13	0	31	4	60	7	1.7	3223	0.18	7.3	3
	Summer Midgrass, Deciduous Tree, Monocot Shrub, Summer Shortgrass, Evergreen Shrub, Summer Rhizomatous Grass, Summer Perennial Forb														
Limy Upland	077E.8.1.1	43	14	7	13	9	16	9	60	24	1.7	1699	0.31	12.4	33
	Summer Shortgrass, Summer Midgrass, Summer Perennial Forb, Summer Rhizomatous Grass, Spring Perennial Forb, Summer Annual Forb, Summer Stoloniferous Grass														
Limy Upland	077E.8.2.1	15	17	25	18	3	15	2	66	28	3.3	2071	0.34	10.2	9
	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Monocot Shrub, Evergreen Shrub, Summer Annual Forb, Cacti														
Limy Upland	077E.8.3.1	35	4	12	13	0	18	1	75	7	0	1384	0.27	12.92	3
	Monocot Shrub, Spring Perennial Forb, Evergreen Shrub, Summer Midgrass, Summer Tallgrass, Deciduous Tree, Summer Shortgrass														
Rocky Slopes	077E.9.1.1	36	13	14	19	9	11	5	56	45	1.3	2195	0.21	8.03	38
	Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Summer Perennial Forb, Summer Annual Forb, Spring Perennial Forb, Summer Tallgrass														
Rocky Slopes	077E.9.2.1	53	7	14	12	4	18	23	61	35	1.4	2039	0.23	8.71	18
	Summer Midgrass, Summer Shortgrass, Monocot Shrub, Summer Perennial Forb, Cacti, Spring Perennial Forb, Evergreen Subshrub														
Rocky Slopes	077E.9.3.1	29	9	19	27	17	18	2	69	48	1.5	2752	0.16	8.63	7
	Monocot Shrub, Summer Midgrass, Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Perennial Forb, Spring Annual Forb(I)														

APPENDIX D. MLRA 77E, REPRESENTATIVE SOIL MAP UNIT COMPONENTS

Bottom Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
TX233	Hutchinson County, Texas	Ln	Lincoln	30962
TX211	Hemphill County, Texas	Ln	Lincoln	22350
OK025	Cimarron County, Oklahoma	Sa	Spur	19212
TX359	Oldham County, Texas	19	Lincoln	17579
OK007	Beaver County, Oklahoma	Ln	Lincoln	15026
TX205	Hartley County, Texas	Ln	Lincoln	12440
NM669	Curry County and Southwest Part of Quay County, New Mexico	BcA	Bippus	11347
NM059	Union County, New Mexico	Bk	Bankard	10239

Breaks Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
OK139	Texas County, Oklahoma	Pt	Potter	55278
TX011	Armstrong County, Texas	Ro	Rough broken land	47664
TX227	Howard County, Texas	Ps	Potter	34949
OK139	Texas County, Oklahoma	Mp	Potter	31383
TX357	Ochiltree County, Texas	PmD	Pastura	23954
TX195	Hansford County, Texas	PGE	Potter	23928

Clayey Upland Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
TX357	Ochiltree County, Texas	RcA	Darrouzett	43012
TX295	Lipscomb County, Texas	DaB	Darrouzett	20275
TX357	Ochiltree County, Texas	RcB	Darrouzett	16428
TX191	Hall County, Texas	TpA	Texroy	15416
TX065	Carson County, Texas	AtB	Alibates	12583

Limy Upland Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
OK139	Texas County, Oklahoma	Mp	Veal	67997
TX359	Oldham County, Texas	8	Berda	41484
OK007	Beaver County, Oklahoma	Mp	Mansker	35458
OK045	Ellis County, Oklahoma	McC	Mansic	34130
TX205	Hartley County, Texas	BRD	Berda	31038
TX179	Gray County, Texas	McD	Veal	30823
TX393	Roberts County, Texas	30	Paloduro	29088

Sandy Upland Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
TX233	Hutchinson County, Texas	LkC	Likes	71728
TX295	Lipscomb County, Texas	DeD	Devol	47537
TX393	Roberts County, Texas	17	Likes	38180
TX211	Hemphill County, Texas	SfB	Springer	26499
OK045	Ellis County, Oklahoma	Lf	Likes	25766
TX375	Potter County, Texas	LeD	Likes	21415

Rocky Slopes Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
OK007	Beaver County, Oklahoma	OpD	Mobeetie	80232
TX393	Roberts County, Texas	23	Mobeetie	49935
TX359	Oldham County, Texas	41	Tascosa	49341
TX129	Donley County, Texas	34	Mobeetie	41348
TX359	Oldham County, Texas	26	Mobeetie	34990
TX065	Carson County, Texas	MVD	Mobeetie	34796

Wet Bottomland Ecological Site Class

Area Symbol	Soil Survey Area	Map Unit	Component	Component Acres
TX211	Hemphill County, Texas	Sw	Sweetwater	8913
TX233	Hutchinson County, Texas	Sw	Sweetwater	4574
TX393	Roberts County, Texas	36	Sweetwater	4216
TX179	Gray County, Texas	Sw	Sweetwater	2182
TX295	Lipscomb County, Texas	Sw	Sweetwater	1619
TX205	Hartley County, Texas	Gm	Gracemore	782

APPENDIX E. MLRA 77E, COMMON PLANTS AND FUNCTIONAL GROUPS

Common Name	Accepted Symbol	Scientific Name	Functional Group
alderleaf mountain mahogany	CEMO2	Cercocarpus montanus	Evergreen Shrub
alkali sacaton	SPAI	Sporobolus airoides	Summer Midgrass
American star-thistle	CEAM2	Centaurea americana	Spring Annual Forb
annual buckwheat	ERAN4	Eriogonum annuum	Summer Annual Forb
Artemesia spp.	ARTEM	Artemisia	Evergreen Shrub
ash	FRAXI	Fraxinus	Deciduous Tree
Baldwin's ironweed	VEBA	Vernonia baldwinii	Summer Perennial Forb
Bermudagrass	CYDA	Cynodon dactylon	Summer Stoloniferous Grass
big bluestem	ANGE	Andropogon gerardii	Summer Tallgrass
black grama	BOER4	Bouteloua eriopoda	Summer Stoloniferous Grass
blazingstar	MENTZ	Mentzelia	Spring Perennial Forb
blue grama	BOGR2	Bouteloua gracilis	Summer Shortgrass
broom snakeweed	GUSA2	Gutierrezia sarothrae	Evergreen Subshrub
broomweed	AMPHI8	Amphiachyris	Summer Perennial Forb
brownseed paspalum	PAPL3	Paspalum plicatulum	Summer Midgrass
buffalobur nightshade	SORO	Solanum rostratum	Spring Annual Forb
Buffalograss	BUDA	Buchloe dactyloides	Summer Rhizomatous Grass
bush morning-glory	IPLE	Ipomoea leptophylla	Summer Perennial Forb
camphorweed	HESU3	Heterotheca subaxillaris	Spring Midgrass
Canada wildrye	ELCA4	Elymus canadensis	Spring Midgrass
Canadian horseweed	COCA5	Conyza canadensis	Spring Annual Forb
cane bluestem	BOBA3	Bothriochloa barbinodis	Summer Midgrass
cane cholla	OPIM	Opuntia imbricata	Cacti
canola	BRRA	Brassica rapa	Crop
Carolina horsenettle	SOCA3	Solanum carolinense	Summer Perennial Forb
Carolina larkspur	DECA3	Delphinium carolinianum	Spring Perennial Forb
Carolina woollywhite	HYSC	Hymenopappus scabiosaeus	Summer Perennial Forb
caterpillars	PHCO2	Phacelia congesta	Summer Annual Forb
Caucasian bluestem	BOBL	Bothriochloa bladhii	Summer Midgrass
Chickasaw plum	PRAN3	Prunus angustifolia	Deciduous Tree
cholla	OPUNT	Opuntia	Cacti
cliff false goldenaster	HEVI5	Heterotheca viscida	Spring Perennial Forb
coastal sandbur	CESP4	Cenchrus spinifex	Summer Annual Forb
cobwebby thistle	CIOC	Cirsium occidentale	Spring Perennial Forb
common buttonbush	CEOC2	Cephalanthus occidentalis	Deciduous Shrub
common sunflower	HEAN3	Helianthus annuus	Summer Annual Forb
composite dropseed	SPCOC2	Sporobolus compositus var. compositus	Summer Midgrass
corn	ZEMA	Zea mays	Crop
cotton	GOHI	Gossypium hirsutum	Crop
Cuman ragweed	AMPS	Ambrosia psilostachya	Summer Perennial Forb
curlytop gumweed	GRNU	Grindelia nuda	Summer Annual Forb
cutleaf nightshade	SOTR	Solanum triflorum	Summer Annual Forb
dense blazing star	LISP	Liatris spicata	Summer Perennial Forb
dotted blazing star	LIPU	Liatris punctata	Summer Perennial Forb
Dyschoriste	DYSCH	Dyschoriste	Spring Perennial Forb
Dyssodia	DYSSO	Dyssodia	Summer Annual Forb
Eastern cottonwood	PODE3	Populus deltoides	Deciduous Tree
eastern daisy fleabane	ERAN	Erigeron annuus	Summer Annual Forb

Common Name	Accepted Symbol	Scientific Name	Functional Group
Eastern gamagrass	TRDA3	Tripsacum dactyloides	Spring Midgrass
eastern redcedar	JUVI	Juniperus virginiana	Evergreen Tree
Echinocereus	ECHIN3	Echinocereus	Cacti
fall witchgrass	DICO6	Digitaria cognata var. cognata	Summer Midgrass
featherplume	DAFO	Dalea formosa	Deciduous Subshrub
field sagewort	ARCA12	Artemisia campestris	Summer Perennial Forb
fragrant sumac	RHAR4	Rhus aromatica	Deciduous Shrub
Franklin's sandwort	ARFR	Arenaria franklinii	Summer Perennial Forb
Gaura	GAVI2	Gaura villosa	Summer Perennial Forb
giant dropseed	SPGI	Sporobolus giganteus	Summer Tallgrass
giant sandreed	CAGI3	Calamovilfa gigantea	Summer Rhizomatous Grass
goats rue	TEVI	Tephrosia virginiana	Summer Perennial Forb
golden currant	RIAU	Ribes aureum	Deciduous Shrub
goldenrod	SOLID	Solidago	Spring Perennial Forb
grama spp.	BUCHL	Bouteloua	Summer Rhizomatous Grass
grassland blazingstar	MEST3	Mentzelia strictissima	Summer Perennial Forb
great ragweed	AMTR	Ambrosia trifida	Summer Annual Forb
greenthread	THELE	Thelesperma	Summer Annual Forb
Gutierrezia	GUTIE	Gutierrezia	Evergreen Subshrub
hackberry	CELTI	Celtis	Deciduous Shrub
hairy false goldenaster	HEVI4	Heterotheca villosa	Spring Perennial Forb
hairy grama	BOHI2	Bouteloua hirsuta	Summer Shortgrass
hairy tridens	ERPI5	Erioneuron pilosum	Summer Shortgrass
hoary false goldenaster	HECA8	Heterotheca canescens	Summer Annual Forb
honey mesquite	PRGL2	Prosopis glandulosa	Deciduous Tree
hooded windmill grass	CHCU2	Chloris cucullata	Summer Annual Grass
Indiangrass	SONU2	Sorghastrum nutans	Summer Tallgrass
Indiangrass	SORGH	Sorghastrum	Summer Tallgrass
Japanese brome	BRJA	Bromus japonicus	Spring Annual Grass(I)
Juniper	JUNIP	Juniperus	Coniferous Tree
kleingrass	PACO2	Panicum coloratum	Summer Midgrass (I)
kochia	KOSC	Kochia scoparia	Spring Annual Forb(I)
lacy tansyaster	MAPI	Machaeranthera pinnatifida	Spring Perennial Forb
lambsquarters	CHAL7	Chenopodium album	Spring Annual Forb
lateflowering thoroughwort	EUSE2	Eupatorium serotinum	Summer Perennial Forb
little barley	HOPU	Hordeum pusillum	Spring Annual Grass
little bluestem	SCSC	Schizachyrium scoparium	Summer Midgrass
littleleaf sumac	RHMI3	Rhus microphylla	Deciduous Shrub
longstalk greenthread	THLO	Thelesperma longipes	Spring Perennial Forb
lotebush	ZIOB	Ziziphus obtusifolia	Deciduous Shrub
mat sandbur	CELO3	Cenchrus longispinus	Summer Annual Forb
meadow milkvetch	ASDI5	Astragalus diversifolius	Summer Perennial Forb
mesa dropseed	SPFL2	Sporobolus flexuosus	Summer Midgrass
Missouri goldenrod	SOMI2	Solidago missouriensis	Summer Perennial Forb
muhly	MUHLE	Muhlenbergia	Summer Midgrass
Narrowleaf bluets	HENI4	Hedyotis nigricans	Summer Perennial Forb
needlegrass	HESPE11	Hesperostipa	Spring Midgrass
New Mexico feathergrass	HENE5	Hesperostipa neomexicana	Spring Midgrass
nightshade	SOLAN	Solanum	Spring Perennial Forb
oneseed juniper	JUMO	Juniperus monosperma	Coniferous Tree
Opuntia spp.	OPUNT	Opuntia	Cacti

Common Name	Accepted Symbol	Scientific Name	Functional Group
Panicum spp	PANIC	Panicum	Summer Annual Grass
plains blackfoot	MELE2	Melampodium leucanthum	Spring Perennial Forb
plains bristlegrass	SEVU2	Setaria vulpiseta	Summer Midgrass
plains pricklypear	OPPO	Opuntia polyacantha	Cacti
plantago	PLANT	Plantago	Spring Annual Forb
Polygonum spp.	POLYG4	Polygonum	Summer Perennial Forb
prairie broomweed	AMDR	Amphiachyris dracunculoides	Summer Annual Forb
prairie cordgrass	SPPE	Spartina pectinata	Summer Tallgrass
prairie fleabane	ERST3	Erigeron strigosus	Summer Annual Forb
prairie sagewort	ARFR4	Artemisia frigida	Evergreen Subshrub
prairie sandreed	CALO	Calamovilfa longifolia	Summer Tallgrass
prairie thermopsis	THRH	Thermopsis rhombifolia	Spring Perennial Forb
prairie threeawn	AROL	Aristida oligantha	Summer Midgrass
prickly pear	OPUNT	Opuntia	Cacti
Prosopis spp.	PROSO	Prosopis	Deciduous Tree
Prunus spp.	PRUNU	Prunus	Deciduous Shrub
Psoralidium	PSORA2	Psoralidium	Spring Perennial Forb
purple monkeyflower	MILE2	Mimulus lewisii	Spring Perennial Forb
purple threeawn	ARPU9	Aristida purpurea	Summer Midgrass
purpletop tridens	TRFL2	Tridens flavus	Summer Midgrass
queen's-delight	STSY	Stillingia sylvatica	Spring Perennial Forb
rabbit-tobacco	PSOB3	Pseudognaphalium obtusifolium	Summer Annual Forb
ragweed	AMBRO	Ambrosia	Summer Annual Forb
red lovegrass	ERSE	Eragrostis secundiflora	Summer Shortgrass
red threeawn	ARPUL	Aristida purpurea var. longiseta	Summer Shortgrass
redberry juniper	JUCO11	Juniperus coahuilensis	Evergreen Tree
Reverchon’s bristlegrass	SERE3	Setaria reverchonii	Summer Midgrass
Rocky Mountain zinnia	ZIGR	Zinnia grandiflora	Evergreen Subshrub
rush milkweed	ASSU	Asclepias subulata	Spring Perennial Forb
Russian olive	ELAN	Elaeagnus angustifolia	Evergreen Tree(I)
Russian thistle	SAKA	Salsola kali	Spring Annual Forb(I)
russian thistle	SALSO	Salsola	Spring Annual Forb(I)
salt cedar	TAMAR2	Tamarix	Deciduous Shrub (I)
salt cedar	TARA	Tamarix ramosissima	Deciduous Tree(I)
sand bluestem	ANHA	Andropogon hallii	Summer Tallgrass
sand dropseed	SPCR	Sporobolus cryptandrus	Summer Midgrass
sand lovegrass	ERTR3	Eragrostis trichodes	Summer Midgrass
sand paspalum	PASE5	Paspalum setaceum	Summer Midgrass
sand sagebrush	ARFI2	Artemisia filifolia	Evergreen Shrub
sand sedge	CAAR16	Carex arenaria	Summer Perennial Grasslike
sandbur	CENCH	Cenchrus	Summer Annual Forb
sawtooth sandmat	CHSE7	Chamaesyce serrula	Summer Annual Forb
scarlet beeblossom	GACO5	Gaura coccinea	Summer Perennial Forb
Schizachyrium	SCHIZ4	Schizachyrium	Summer Midgrass
Scribner’s dicanthelium	DIOLS	Dichanthelium oligosanthes	Spring Perennial Midgrass
sedge	CYPER	Cyperus	Summer Perennial Grasslike
shinnery oak	QUHA3	Quercus havardii	Deciduous Shrub
sideoats grama	BOCU	Bouteloua curtipendula	Summer Midgrass
silver beardgrass	BOLA2	Bothriochloa laguroides	Summer Midgrass
silver bluestem	BOSA	Bothriochloa saccharoides	Summer Midgrass
silverleaf nightshade	SOEL	Solanum elaeagnifolium	Spring Perennial Forb

Common Name	Accepted Symbol	Scientific Name	Functional Group
sixweeks fescue	VUOC	Vulpia octoflora	Spring Annual Grass
skunkbush sumac	RHTR	Rhus trilobata	Deciduous Shrub
slender scratchdaisy	CRDI17	Croptilon divaricatum	Summer Annual Forb
slim tridens	TRMU	Tridens muticus	Summer Shortgrass
slimflower scurfpea	PSTE5	Psoralidium tenuiflorum	Summer Perennial Forb
slimleaf prairie clover	DATE5	Dalea tenuifolia	Deciduous Shrub
smooth brome	BRIN2	Bromus inermis	Spring Rhizomatous Grass(I)
snow on the mountain	EUMA8	Euphorbia marginata	Summer Annual Forb
soapweed yucca	YUGL	Yucca glauca	Monocot Shrub
sorghum	SOBI2	Sorghum bicolor	Crop
soybeans	GLMA4	Glycine max	Crop
Sporobolus spp.	SPORO	Sporobolus	Summer Midgrass
stemmy four-nerve daisy	TESC2	Tetraneuris scaposa	Spring Perennial Forb
sunflower	HELIA3	Helianthus	Summer Annual Forb
sunflower	HELIA3	Helianthus	Summer Annual Forb
switchgrass	PAVI2	Panicum virgatum	Summer Tallgrass
tall dropseed	SPCO16	Sporobolus compositus	Summer Tallgrass
tall woolly buckwheat	EREL5	Eriogonum elatum	Spring Perennial Forb
tanseyleaf tansyaster	MATA2	Machaeranthera tanacetifolia	Spring Perennial Forb
Texas bluegrass	POAR	Poa arachnifera	Spring Rhizomatous Grass
Texas blueweed	HECI	Helianthus ciliaris	Summer Perennial Forb
Texas croton	CRTE4	Croton texensis	Spring Annual Forb
Texas grama	BORI	Bouteloua rigidiseta	Summer Shortgrass
Texas wintergrass	NALE3	Nassella leucotricha	Spring Midgrass
thin paspalum	PASE5	Paspalum setaceum	Summer Shortgrass
Threeawn	ARIST	Aristida	Summer Midgrass
tobosagrass	PLMU3	Pleuraphis mutica	Summer Rhizomatous Grass
touristplant	DIWI2	Dimorphocarpa wislizeni	Spring Annual Forb
trailing krameria	KRLA	Krameria lanceolata	Evergreen Subshrub
tridens	TRIDE	Tridens	Summer Shortgrass
tumble windmill grass	CHVE2	Chloris verticillata	Summer Annual Grass
tumblegrass	SCPA	Schedonnardus paniculatus	Summer Midgrass
vine mesquite	PAOB	Panicum obtusum	Summer Rhizomatous Grass
wavyleaf thistle	CIUN	Cirsium undulatum	Summer Perennial Forb
weeping lovegrass	ERCU2	Eragrostis curvula	Spring Midgrass(I)
western ragweed	AMPS	Ambrosia psilostachya	Summer Perennial Forb
western wheatgrass	PASM	Pascopyrum smithii	Spring Rhizomatous Grass
wheat	TRITI	Triticum	Spring Annual Grass(I)
white sagebrush	ARLU	Artemisia ludoviciana	Summer Perennial Forb
white tridens	TRAL2	Tridens albescens	Spring Rhizomatous Grass
willow baccharis	BASA	Baccharis salicina	Deciduous Shrub
wingleaf soapberry	SASA4	Sapindus saponaria	Deciduous Tree
winterfat	KRLA2	Krascheninnikovia lanata	Evergreen Subshrub
woolly paperflower	PSTA	Psilostrophe tagetina	Evergreen Subshrub
wooly croton	CRCA6	Croton capitatus	Summer Annual Forb
Wright's plantain	PLWR	Plantago wrightiana	Summer Annual Forb
Wright's skullcap	SCWR2	Scutellaria wrightii	Spring Perennial Forb
yellow bluestem	BOIS	Bothriochloa ischaemum	Summer Midgrass(I)
Yucca spp.	YUCCA	Yucca	Monocot Shrub

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ACKNOWLEDGEMENTS

This material is based upon work supported by the Conservation Effects Assessment Project (CEAP)-Grazing Lands, Natural Resources Conservation Service, U.S. Department of Agriculture, under agreement number 67-3A75-15-152.

It was developed in Calendar Year 2016 using NRI Rangeland On-Site Data from 2004-2011, and ecological site and soil survey data available in that year.

Many highly dedicated and talented individuals helped with this project. At the risk of leaving out some of the individuals who contributed, Loretta Metz, Steve Barker, and Pat Shaver would like to thank the following people for their input and support.

Salvador Salinas, NRCS State Conservationist, TX
Joel Brown, NRCS NEST, Las Cruces NM
Brandon Bestelmeyer, ARS Las Cruces NM
Phil Heilman, ARS Tucson AZ
Mark Nearing, ARS Tucson AZ
Mariano Hernandez, ARS Tucson AZ
Ken Spaeth, NRCS Ft. Worth TX
Clint Rollins, NRCS Amarillo TX
Stan Bradbury, NRCS Lubbock TX
J.R. Bell, NRCS Retired
Kelly Attebury, NRCS Lubbock TX
Darren Richardson, NRCS Lubbock TX
Gary O'Neill, NRCS State Conservationist, OK
Brandon Reavis, NRCS Stillwater OK
Steve McGowen, NRCS Woodward OK
Chris Hobbs, NRCS Woodward OK