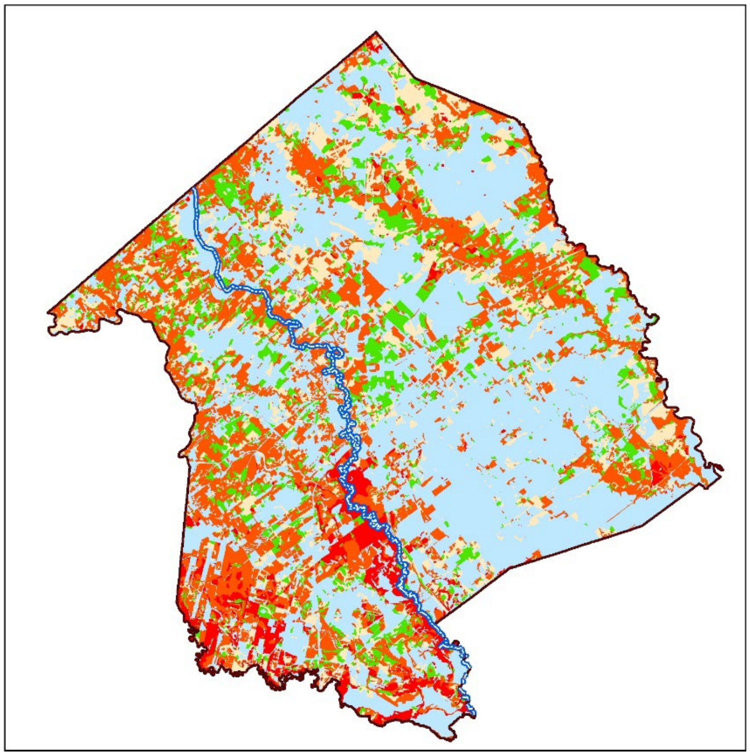
# DEVELOPMENT OF AN EDYS ECOLOGICAL MODEL FOR VICTORIA COUNTY, TEXAS

## FINAL REPORT



**PREPARED FOR:**

**SAN ANTONIO RIVER AUTHORITY**

**AND**

**TEXAS STATE SOIL AND WATER CONSERVATION BOARD**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| | |
|---|---|
| **ANWR** | Aransas National Wildlife Refuge |
| **AU** | Animal unit |
| **AUD** | Animal unit day |
| **BC** | Brush control |
| **CRoot** | Coarse root |
| **DEM** | Digital Elevation Model |
| **DTW** | Depth to groundwater |
| **EDYS** | Ecological Dynamics Simulation model |
| **ET** | Evapotranspiration |
| **FRoot** | Fine root |
| **GW** | Groundwater |
| **HILF** | High-intensity low-frequency grazing system |
| **LIDAR** | Light Detection and Ranging – remote sensing method for determining elevations |
| **MODFLOW** | Groundwater flow simulation model |
| **Musym** | Map unit symbol – identifiers for individual soil series on Soil Surveys |
| **NAIP** | National Agriculture Imagery Program |
| **NRCS** | Natural Resources Conservation Service |
| **NWR** | National wildlife refuge |
| **PPT** | Precipitation |
| **RO** | Runoff |
| **SARA** | San Antonio River Authority |
| **SdlgRoot** | Seedling root |
| **SdlgShoot** | Seedling shoot |
| **SDLeaf** | Standing dead leaves |
| **SDStem** | Standing dead stems |
| **TSSWCB** | Texas State Soil and Water Conservation Board |
| **USDA** | United States Department of Agriculture |
| **USGS** | United States Geological Survey |
| **WSEP** | Water Supply Enhancement Program |
| **WWR** | Welder Wildlife Refuge |

## EXECUTIVE SUMMARY

The Texas State Soil and Water Conservation Board (TSSWCB) is interested in the development of county-wide simulation models that allow for the evaluation of brush management scenarios which can positively impact water yield. In particular, the TSSWCB is interested in these models being used to evaluate potential enhanced water yields from control of woody species. The TSSWCB selected Victoria County as one of the counties for development of such a model, and has co-operated with the San Antonio River Authority (SARA) in its development.

SARA participated with the TSSWCB in this effort so as to obtain an integrated set of ecological simulation models for the San Antonio River system. To accomplish this, EDYS ecological models are being developed for each county along the San Antonio River. The first three models of this project were developed for Goliad, Karnes and Wilson counties. This report presents the description of the fourth model in the series, Victoria County, along with the calibration process and ecological and hycrological results from ten land management simulation scenarios.

### Description of the Model

Victoria County covers about 889 mi$^2$ (568,787 acres) located in the central part of the Texas Coastal Prairies. The San Antonio River forms the southwestern boundary of Victoria County.

The basic spatial unit of the EDYS model is the cell. The cell size for the San Antonio River models is 40 m x 40 m (0.40 acre). This discretization results in the Victoria County model containing about 1.44 million cells. Each cell contains data on topography, soil, depth to groundwater, vegetation, and land use.

Surface topography in the model is defined by an average elevation for each cell, with slope and aspect determined by differences in elevation among adjacent cells. The elevation data used in the Victoria County model are USGS 10-m DEM. Each cell also has an average depth to groundwater value, from which a depth to groundwater grid is defined for the county.

The model simulates rainfall on a daily basis. A 122-year (1893-2014) daily precipitation record was created based on statistical relationships among recorded precipitation data from the recorded Victoria rainfall data plus recorded data from three nearby stations (Cuero, Goliad, and Runge).

A detailed soil profile description was assigned to each of the 1.44 million cells in the model. These profiles were developed from NRCS soil survey descriptions of Victoria County soils and from additional data available in the literature. Nineteen soil types are included in the Victoria County model, and each cell is assigned to one of the 19 types based on the location of the cell on the spatial landscape. Each of the 19 soil types is divided into 35 layers, with the thickness and physical and chemical characteristics of each layer varying among the types. Some of the soil variables remain constant throughout a simulation (e.g., soil texture) while values of other variables (e.g., soil moisture) change by layer on a daily basis depending on environmental factors such as amount of rainfall received and amount of water and nutrients extracted by plants.

The number of plant species included in a specific EDYS application is flexible. A total of 66 species are included in the Victoria County model. Dynamics of each species are modeled by use of 346 parameter variables, with each variable having different values for each species. Changes in vegetation are modeled in EDYS on a plant species (or plant part) basis by simulating differential responses, defined by the different parameter values, to changes in environmental factors (e.g., rainfall, grazing, season).

The spatial footprint of the model was initially divided into plant communities and land management units (e.g., cultivated, urban, road) by assigning each cell type to one of 26 plot types (vegetation and land-use types). The locations of the vegetation types were based on Natural Resources Conservation Service (NRCS) soil survey maps, and the locations of land-use types were based on 2012 National Agriculture Imagery Program (NAIP) aerial photographs. Each vegetation type was further divided based on amount of woody plant cover present, with these values visually estimated from the 2012 NAIP aerial photographs. Initial (i.e., start of a simulation) biomass values were entered for each plant species in each plot type, based on species composition for each type. Biomass (above- and below-ground) values change for each plant species and each plant part (e.g., fine roots, trunks, leaves) per species at each time step (daily) during an EDYS simulation.

The animal component in EDYS models consists of the effects of herbivory by different types of animals, both domestic and wildlife, on the vegetation. Herbivory is modeled as a plant-part and plant-species specific process, where selection of plant parts and plant species varies by animal species and the specifics of the vegetation present. Densities of each animal species are entered and the model calculates the quantity of plant material the animals would consume daily and then determines how much of each species is removed based on selectivity, accessibility, and competitiveness among the animals. Four animal species (or groups) are included in the Victoria County model: cattle, deer, rabbits, and insects. An average white-tailed deer density of 1 deer per 15 acres was used in the model. Cattle stocking rates were calculated for each vegetation type and averaged 19.1 acres/AU for native rangeland with existing woody-plant cover. Horses and feral hogs can be added but were not included in the model because of lack of information on densities and distributions of these two species.

## Calibration

Calibration in EDYS consists of making adjustments of parameter values, if needed, to achieve target values for the output variables under consideration. Target values are taken from independent validation data, either experimental validation studies or existing field data, if these data are available. In the absence of independent validation data, values from the literature and values based on professional judgement are used.

Only very limited independent validation data are currently available for Victoria County. Therefore, data from published studies in South Texas and the Central Texas Coast and professional judgement were used to calibrate the vegetation and hydrologic dynamics of the model. Ten-year simulations for six plot types (plant communities) were used in the vegetation calibration process. Results of simulated vegetation change in response to fluctuations in rainfall, grazing, and time (succession) were compared to published results from 23 studies and to our professional experience in the region. The simulation results compared favorably to the patterns and levels expected from these studies and regional experience. Under the moderate rainfall regime and with livestock grazing (moderate stocking rate), there was a 6% increase in overall biomass on the blackland type at the end of the 10-year simulation. Huisache increased by 25% and there were smaller increases in mesquite and Macartney rose. Midgrasses decreased 17% and shortgrasses increased by 5%. Two midgrasses (sideoats grama and little bluestem) and three shortgrasses (purple threeawn, buffalograss, and knotroot bristlegrass) were the grasses that increased the most. Forage production in the simulations (tenth year) was 242, 403, and 552 $g/m^2$ on the loamy prairie, sandy loam, and cordgrass types, respectively, compared to 249, 542, and 543 $g/m^2$ on similar sites reported in literature studies in South Texas.

Simulated amounts of evapotranspiration (ET) and surface runoff were compared to literature values for the region and for similar types of vegetation. The simulated ET values corresponded well with reported values in the literature. On the blackland type (38% average woody plant cover), ET averaged 2.5 mm/day, compared to 2.6 mm/day on a mesquite-granjeno site in South Texas. The simulated ET was equal to 96% of annual rainfall compared to 94-97% on sites with similar vegetation reported in the literature. Annual average ET on the four upland communities simulated in the model varied between 33.2-40.0 inches compared to annual rates of 31.7-33.7 inches reported for shrub-grasslands in Texas without the influence of groundwater. Groundwater was shallow in many areas of the Victoria County spatial footprint, and the four upland communities used in the calibration had an annual average groundwater use of 3.9 inches in the EDYS output for plant dynamics, which was included in the simulated ET values.

Simulated runoff values also compared favorably with published values. For example, annual runoff on the sandy loam type in the 10-year baseline calibration simulation was 2.1 inches, or 5.7% of annual rainfall. This compares with 2.6 inches per year and 4.1% of annual rainfall for a two-year USGS gauged study on a loamy sand rangeland site in San Patricio County. Annual runoff averaged over the six plant communities used in the simulation, which included two bottomland types, over the 10 years was 4.4 inches, or 11.7% of annual rainfall.

Data from the two USGS gauge stations on watersheds located almost entirely within Victoria County were used to compare measured flow rates with surface runoff in the EDYS simulations. A five-year data set (1999-2003) was used. Summed over the five years, the gauged flow at the Placedo station (central Victoria County watershed) was equal to 18% of rainfall and the gauged flow at the Garcitas station (northern Victoria County watershed) was equal to 16% of rainfall. In general, flow increased as rainfall increased, but the ratio between monthly flow and monthly rainfall varied considerably, both overall and within rainfall group classes (low, moderate, high).

Average runoff in the EDYS simulations was equal to 80.1 $ft^3$/acre/inch of rainfall received. This compares favorably with a two-year average of 90.0 $ft^3$/acre/inch calculated from the data for the two USGS gauged watersheds in San Patricio County. The EDYS simulations resulted in average runoff:rainfall ratios of 0.034 (3.4%) for the Placedo watershed and 0.020 (2.0%) for the Garcitas watershed, compared to ratios of 0.011-0.045 (1.1-4.5%) for the gauged San Patricio County watersheds. These results indicate that the Victoria EDYS model is producing realistic runoff values. Applying these runoff amounts to contributions to flow in the two watersheds, the simulated runoff accounted for 19% of gauged flow in the Placedo watershed and 13% of gauged flow in the Garcitas watershed.

**Results**

Ten 25-year scenarios were simulated as examples of how the models can be used. Three scenarios were included to illustrate the response to fluctuations in rainfall patterns. Only rainfall was varied in these three scenarios. One was baseline, which used the rainfall data from the 25 continuous years (1962-1985) that had a mean nearest the long-term mean. The second scenario used the rainfall data from the driest 25 continous years (1932-1956), and the third scenario used the rainfall data from the wettest 25 continuous years (1983-2007). Two scenarios illustrated effects of cattle grazing. Both of these scenarios used the moderate rainfall regime used in Scenario 1, but also included grazing by cattle. Cattle grazing was not included in the first three scenarios. In Scenario 4, a moderate stocking rate was used, and a heavy stocking rate was used in Scenario 5. The last five scenarios illustrated responses to brush management with moderate cattle stocking rates. Scenario 6 was used to illustrate the effect of removing only huisache (90% removal) under the moderate rainfall regime. Scenario 7 was similar except that 90% of Macartney rose was removed instead of huisache. In Scenario 8, 90% of all woody species (except only 50% of live oak) were removed, with the moderate rainfall regime. Scenario 9 was similar except that the dry rainfall regime was used, and the wet rainfall regime was used in Scenario 10. In each of the last five scenarios, the brush removal was simulated in the first year only with the woody species allowed to regrow following initial treatment. The report presents the results of each of these ten scenarios on vegetation and hydrology.

Vegetation Changes

Vegetation change in the simulation scenarios varied by plot type and management scenario. Results are presented for the six major vegetation (plot) types. Under the baseline scenario (moderate rainfall regime, no cattle grazing, and no brush control), huisache more than doubled over the 25 years on the types where it was abundant at the beginning of the simulation. Herbaceous biomass decreased on these types in response to the increase in huisache but not uniformly among types. On some types, herbaceous biomass increased during the first 15 years and then decreased as huisache became more dominant. There were also major compositional shifts in the herbaceous communities, reflecting both successional responses and responses to the increase in huisache.

Unlike the four types where huisache increased substantially under the basline scenario, huisache abundance was low on the sandy loam type at the beginning of the simulation. On this type, huisache decreased in biomass in response to a major increase in midgrasses, particularly little bluestem, in the absence of grazing. Species composition also changed over time in this type, with little bluestem increasing from 21% relative biomass initially to 67% after 25 years, and there was a corresponding decrease in the composition of earlier successional species and an increase in later successional species such as sideoats grama.

The sixth vegetation type for which results are presented is the loamy bottomland type, which is a primary riparian woodland type in Victoria County. On this type, tree biomass slowly decreased over the 25 years in the baseline scenario. The decline was most rapid in early- or mid-seral species such as huisache, mesquite, and sugar hackberry, and slowest in the late-seral live oak and pecan. The slow decline in tree biomass over the 25 years suggests that this rainfall regime (average of 37 inches per year) is inadequate to support these woodlands over longer periods (e.g., $100^+$ years) and that they may have been established under a previous, wetter climatic regime. This result supports similar suggestions from other researchers.

Overall, the vegetation responses, both biomass and species composition, reflected expected ecological responses. Total aboveground biomass, averaged over the six representative types, was lower (6%) under the dry rainfall regime and higher (9%) under the wet regime than under the moderate (baseline) rainfall regime at the end of 25 years. The rainfall regimes had the least effect on trees, in large part because of the stabilizing effect of groundwater-use by this lifeform. Midgrasses and grass-likes had lower biomass under the dry regime and higher biomass under the wet regime, as expected. Macartney rose was the major shrub species, and it had lower biomass under the dry regime because of less available water, but also had lower biomass under the higher regime because of competition from huisache and the midgrasses. Shortgrasses and forbs had lower biomass under both dry and wet regimes, compared to the moderate regime, because of competitive differences among species in each of the two lifeforms.

Vegetation response to moderate grazing by cattle varied by vegetation type. Aboveground biomass of grasses decreased, compared to the ungrazed scenario, on the sandy loam, loamy bottomland, and salty bottomland types, but increased on the blackland, claypan prairie, and loamy prairie types. Under the heavy grazing scenario (150% of moderate stocking rate), grass biomass decreased on all six vegetation types. Overall, midgrasses decreased 15% under heavy grazing compared to moderate grazing, and huisache and mesquite increased more rapidly under heavy grazing than under moderate grazing.

Scenario 6 removed 90% of huisache biomass in the first year of the simulation. In response to this decrease in huisache, there were increases in Macartney rose and baccharis, as well as increases in herbaceous biomass. Midgrasses almost doubled following huisache control, but most of this increase was from increases in earlier-seral species such as Johnsongrass and smutgrass. Other midgrasses that increased by lesser amounts were little bluestem, bushy bluestem, plains bristlegrass, sideoats grama, and Panamerican balsamscale. The removal of 90% of Macartney rose resulted in less of an increase in midgrasses (22%) than did removal of huisache because of an increase in huisache following removal of Macartney rose.

Removal of 90% of all woody species (except only 50% of live oak) resulted in an increase in grasses and grass-likes and a small decrease in forbs when averaged over the six types and over the 25 years. However, specific responses varied by species and by vegetation type. Smutgrass was the grass species that increased the most. Other grasses that increased overall were Johnsongrass, plains bristlegrass, little bluestem, bushy bluestem, sideoats grama, indiangrass, Panamerican balsamscale, and gulf cordgrass. Shortgrasses, especially purple threeawn and buffalograss, tended to decrease in response to increased competition from the midgrasses. Woody species began to recover during the 25 years, with sugar hackberry and Macartney rose increasing most rapidly.

Moisture regime had minimal effect on recovery of woody species following brush control, except for Macartney rose, which increased more rapidly under the wet regime. Grasses also increased more rapidly under the wet regime following brush control, but the response patterns of the various species varied by vegetation type, in part because of competitive relationships with other species.

Ecohydrology

Averaged over the entire county and under the moderate rainfall regime, an average of 2.8% of annual rainfall entered the creeks and river as surface runoff under the baseline scenario, and ET accounted for an average of 142% of annual rainfall. This high ET rate was the result of high groundwater use by vegetation. There was also high annual variability in runoff and ET because of variability in annual rainfall. In the 25-year moderate rainfall regime, annual rainfall varied between 22.1 and 49.3 inches, annual surface runoff varied between less than 7,000 acre-feet to more than 106,000 acre-feet, and annual ET varied between 2.0 million acre-feet (131% of rainfall that year) and 2.9 million acre-feet (126% of rainfall that year). Annual groundwater use by vegetation varied between 367,000 and 686,000 acre-feet, with an annual average of 482,000 acre-feet (10.2 inches per year). The TSSWCB's Water Supply Enhancement Program (WSEP) requires 15-year ecohydrological model simulations for estimation of enhanced average annual yield of water caused by brush removal management strategies. Each component of the water balance was extracted from the EDYS outputs for the first 15 years of the pertinent scenarios. During the first 15 years of the simulation, groundwater use by vegetation averaged 525,000 acre-feet per year (11.1 inches per year). The same approach was used for the other components and scenarios that follow.

Under the dry regime, surface runoff decreased by an average of 38% compared to baseline, while surface runoff increased by an average of 13% over baseline under the wet regime. Moderate grazing by cattle increased surface runoff by 6% averaged over the first 15 years and by 5% averaged over 25 years. Brush control also increased surface runoff, with the greatest increase occurring when 90% of all woody species (50% of live oak) were removed. Under this scenario, average annual surface runoff increased by 1% (695 acre-feet) averaged over 15 years and 4% (2,017 acre-feet) averaged over 25 years.

Evapotranspiration (ET) averaged 52.7 inches per year (142% of annual rainfall) under baseline conditions, or an annual average of about 2,525,000 acre-feet. Brush control reduced this substantially. Averaged over the first 15 years, the 90% woody species removal (moderate rainfall regime) reduced ET to an annual average of 1,807,000 acre-feet (38.8 inches = 103.6% of average annual rainfall), or an annual reduction of about 620,000 acre-feet (26% reduction). Averaged over 25 years, annual average ET was 1,760,000 acre-feet (37.7 inches = 98.2% of average annual rainfall), or an annual reduction of about 607,000 acre-feet (26% reduction).

The reduction in ET following brush control was the result of two factors: 1) reduced plant biomass during the initial years of the simulations and 2) changes in species composition. Following brush control, there was less biomass of woody species. These species were the primary users of groundwater. This reduction in groundwater use shifted the system to a more rainfall-dependent system. Without brush control, average annual ET was 142% of annual rainfall. Following brush control, average annual ET was 98% of annual rainfall (averaged over 25 years).

There was a negative annual water balance under all scenarios except those in which 90% of all woody species (except 50% of live oak) were removed. This result was due to high groundwater use and depletion of stored soil moisture. When averaged over both 15 and 25 years, the annual deficits were greatest under the dry regimes and least under the wet regimes. Under the moderate rainfall regime and with moderate grazing by cattle, the average 15-year deficit was 222,106 acre-feet, and the average 25-year deficit was 173,831 acre-feet. A negative annual water balance cannot be maintained indefinitely. Either more groundwater will be used, or water use by the vegetation will decrease, the latter of which will lead to a reduction in vegetation structure and production. Much of this negative balance is likely the result of an increase in woody species over the past 25-50 years.

When 90% of the woody species (50% of live oak) were removed in the first year, the average annual water balance became positive. When averaged over 15 years, the average annual net balance was 90,826 acre-feet under the moderate rainfall regime, 38,691 acre-feet under the dry regime, and 130,260 acre-feet under the wet regime. When averaged over 25 years, the moderate rainfall regime resulted in an average annual surplus of 149,495 acre-feet, and the wet regime resulted in an average annual surplus of 178,859 acre-feet. The dry regime resulted in a slight negative annual balance (-3,797 acre-feet) when averaged over 25 years. The average annual surplus under the moderate rainall regime was equal to 5.1% of annual rainfall averaged over 15 years and 8.2% of annual rainfall when averaged over 25 years. The huisache-only brush control scenario did not result in a positive annual water balance but did reduce the deficit over the no-brush control scenario. The Macartney rose-only brush control scenario also reduced the deficit when averaged over 15 years, but not when averaged over 25 years.

There were 46 delineated watersheds used in the Victoria County EDYS model, varying in size from 10 acres to more than 40,000 acres. Surface runoff, ET, groundwater-use, and potential enhanced water yield from brush control varied considerably among these 46 watersheds. Maximum potential enhancement of water yield from brush control for the entire county was 671,399 acre-feet per year, averaged over the first 15 years following brush control, or an average of 13.1 inches per acre annually, based on the model simulations. This amount was equal to about 25.6% of total ET without brush control. Nine of the 46 watersheds (20%) had potential average increased annual yields of less than 6 inches per year, 14 (30%) had between 6-12 inches, 9 (20%) had between 12-24 inches, and 14 (30%) more than 24 inches per year. When averaged over 25 years, the maximum potential enhancement of water yield from brush control for the entire county was 604,819 acre-feet, or 12.9 inches per year.

## Summary

The Victoria County EDYS model provides a tool that is useful for quantifying vegetation and hydrologic responses to various environmental and management changes, especially relative differences between scenarios. Vegetation dynamics, as changes in both production and species composition, are simulated in an ecologically reasonable manner, with results comparable with those from published research studies. Flow and surface runoff dynamics fit both patterns and amounts indicated by gauged data and published literature values. ET values are comparable with published values, and responses to changes in rainfall and vegetation management are ecologically reasonable and consistent with published values.

Under current vegetation composition and with a simulated rainfall regime most similar to average rainfall for the county over the past century, there is a negative water balance in most years, i.e., ET exceeds rainfall in most years. This high ET is maintained because of heavy use of groundwater by the vegetation. Under the scenario in which 90% of woody species (but only 50% of live oak) were removed in the first year, but allowing regrowth in subsequent years, there would be a positive water balance in most years, in large part because of the reduction in groundwater-use by the deep-rooted woody species. Although the simulations were conducted for only 25 years, the annual water balances were still evident at the end of the 25 years and would therefore be expected to continue for a longer period.

## 1.0 INTRODUCTION

The San Antonio River begins in Bexar County and flows southeastward through five counties before merging with the Guadalupe River and then flowing into San Antonio Bay on the central Texas Coast. The San Antonio River forms a portion of the southern boundary of Victoria County before merging with the Guadalupe River (Fig. 1.1).

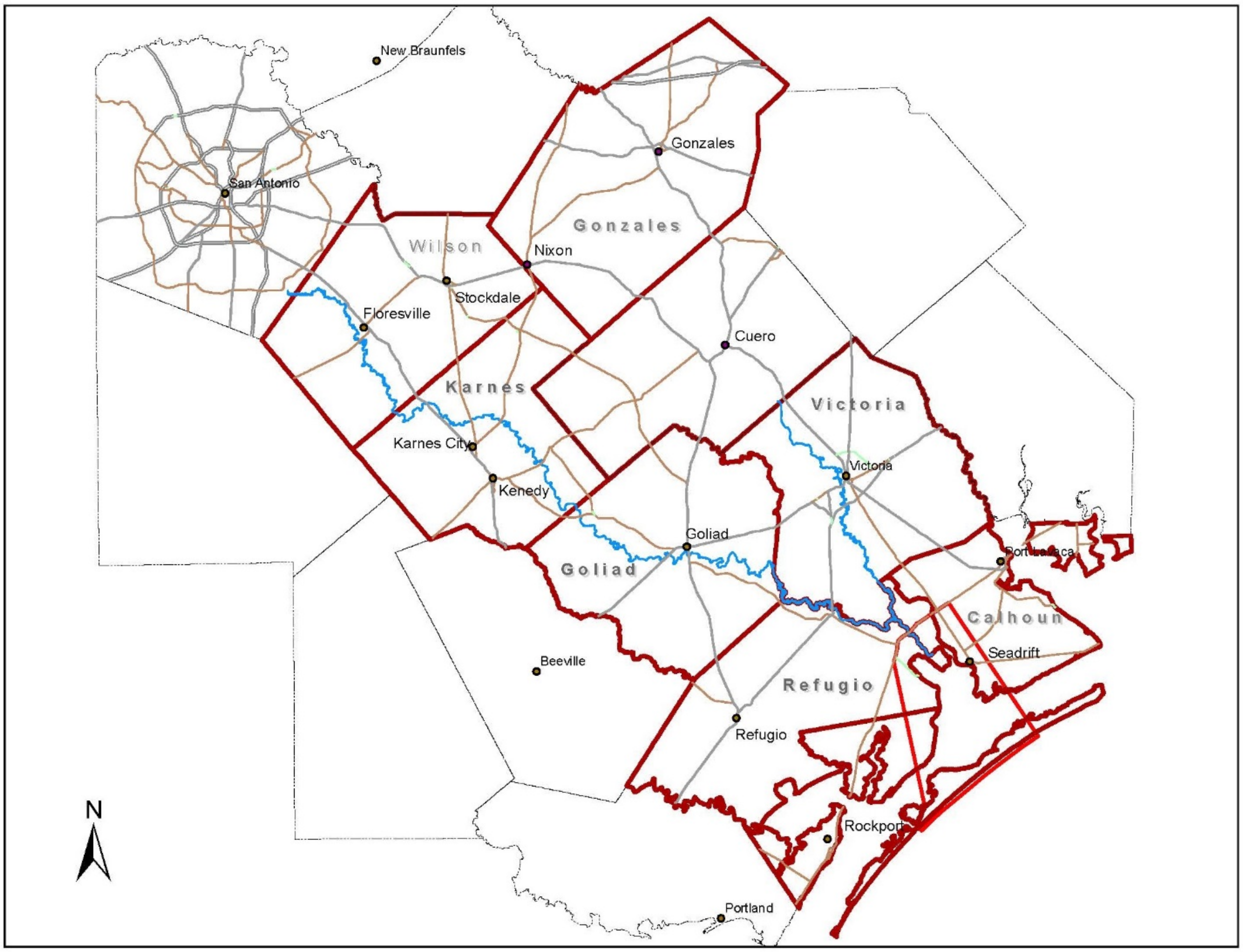


**Figure 1.1 Map of the region of the San Antonio River watershed.**

The San Antonio River Authority (SARA) is concerned with water quality and water quantity in the San Antonio River and its tributaries. The quality and quantity of river water are affected by both in-stream factors and characteristics of the respective watersheds. SARA recognizes the importance of understanding the effects of in-stream responses and watershed ecohydrology to making good management decisions relative to the San Antonio River system.

Natural and anthropogenic changes across the landscape can have major impacts on the water quality and quantity of the river. Management tools that integrate spatial and temporal ecological dynamics at multi-species and multi-scale levels provide valuable support to the environmental decision-making process. Ecological simulation modeling is a tool that allows complex hydrologic, ecological, and management responses to be integrated in a practical and scientifically valid manner, the results of which can substantially improve land-use planning and decision making.

SARA is interested in developing an integrated set of ecological models for the entire San Antonio River system to support their decision-making process related to the management of the San Antonio River. In June 2011, SARA began the application of the EDYS model to San Antonio Bay as the first step in developing this set of integrated ecological models. EDYS is a mechanistic, spatially-explict, dynamic ecosystem simulation model that has been widely applied to land management decision making (Ash and Walker 1999; Childress and McLendon 1999; Childress et al. 1999a, 2002; USAFA 2000; McLendon et al. 2000, 2012e, 2015, 2017; MWH 2003; Chiles and McLendon 2004; Price et al. 2004; McLendon and Coldren 2005, 2011; Naumburg et al. 2005; Amerikanuak, Inc. 2006; Johnson and Coldren 2006; Johnson and Gerald 2006; Mata-Gonzalez et al. 2007, 2008; Coldren et al. 2011a, 2011b; HDR 2015; Broad et al. 2016). In June 2013, SARA began the expansion of this model development to include up-river segments of the linked river-bay system. Karnes and Wilson counties were selected as the first two counties to be included in the integrated model complex. These two models were completed in December 2014 (McLendon et al. 2015). In September 2013, SARA expanded work on the linked-model complex to include Goliad, Refugio, and Victoria Counties. The Goliad County model was completed in August 2016 (McLendon et al. 2016).

The Texas State Soil and Water Conservation Board (TSSWCB) is also interested in the development of county-wide simulation models. In particular, TSSWCB is interested in the development and application of simulation models to be used to evaluate potential enhanced water yields from control of woody species. TSSWCB previously supplied funding for the development of EDYS models for Gonzales County (McLendon et al. 2012e; McLendon 2013) and most of Edwards, Kimble, Real, and Sutton counties (McLendon et al. 2017). In August 2013, TSSWCB provided funds to supplement those provided by SARA to develop EDYS models for Goliad and Victoria Counties.

This document reports the results of the development of an EDYS model for Victoria County. It provides an overview of the model and presents results of a set of simulation scenarios.

## 2.0 SPATIAL FOOTPRINT

Victoria County covers 888.7 mi$^2$ (568,787 acres) located in the central part of the Texas Coastal Prairies (Hatch et al. 1990). The San Antonio River forms most of the southwestern boundary of Victoria County (Fig. 1.1). The Guadalupe River flows through the center of Victoria County and merges with the San Antonio River at the southeastern tip of the county. From the confluence, it is about 12 miles until the combined flow discharges into San Antonio Bay.

In EDYS, the spatial footprint or domain is divided into cells. A cell is the smallest unit that EDYS simulates in a particular application, and it can be of any size, determined by the requirements of the application. EDYS averages values for each variable across an individual cell, therefore the cell size selected is a balance between 1) the largest size for which average values are acceptable and 2) reasonable simulation run times and memory requirements. The smaller the cell size, the more spatially precise the simulation is. However, smaller cell sizes result in more cells, and a larger number of cells results in a slower run time per time step and more memory requirements.

The primary cell size selected for the Victoria County model is 40 m x 40 m (0.40 acre), resulting in approximately 1.44 million cells in the model. The following components (discussed in following sections) are included for each cell: topography (elevation, slope, aspect), soil, depth to groundwater, vegetation, and land use.

A practical upper limit for efficient EDYS operation (relative to run time and memory requirement) on appropriate PCs is about 1.5 million cells. Combining multiple counties into a single model and retaining the 40 m x 40 m cell size is impractical because the spatial domain increases to well over 1.5 million cells. The alternative approach is to keep each county model separate and then link the models, where output from one model can be used as input into another model. This approach has two primary advantages. First, it allows large spatial domains to be included with small cell sizes. Secondly, it allows for separate individual models that can be run either as linked models or separately as individual models. An advantage in having separate models available is that simulations can be run for the separate domains much faster than if there was only one large model. Having separate, but linked, models for each county also allows the linked model to be easily expanded so that additional counties (e.g., Goliad, Gonzales, Karnes, and Wilson) can be added.

EDYS has the ability to simulate selected areas at a finer resolution than the primary cell size used in the overall model. This capability is particularly useful for simulating ecological dynamics in critical areas where the smaller scale becomes important (e.g., some aquatic systems, critical habitat areas, urban development patterns). These critical areas have not yet been defined for the needs of SARA and TSSWCB in Victoria County. One of the purposes of developing the current models may be to investigate some of these areas. Once these areas are identified, finer-scale models can be developed for them and then added to the larger-scale model. The fine-scale models (1 m x 1 m cell size) developed for the validation plots in Atascosa, Karnes, and Goliad counties and the San Antonio Bay model are examples of this approach.

## 3.0 TOPOGRAPHY

Surface topography is an important component in EDYS simulations. It controls the flow pattern and velocity of runoff water, inundation depth of flood water, water depth in ponds and lakes, and tidal depths and patterns in coastal wetlands, and it influences movement patterns for some wildlife species, foot and vehicle traffic, some management options (e.g., limitations to mechanical brush control), and fire events.

Elevation, slope, and aspect are the three topographic variables used in EDYS. All three are derived by EDYS from input elevation data. Surface topography is developed in EDYS based on differences in elevations among adjacent cells. Average elevation (USGS DEMs, or LIDAR data if available) is entered for each cell. From these elevations, EDYS determines slope (angle from horizontal) and aspect (direction). Differences in elevation among adjacent cells allow water to move from higher elevations to lower elevations, and the greater the difference in elevation between two cells, the higher the velocity the water moves downslope and hence the greater the erosive potential and sediment carrying capacity. Direction of the difference in elevation (i.e., aspect) determines the direction of surface flow.

Initial elevations are entered from DEM or LIDAR data. For the Victoria County model, USGS DEM data at 10-m resolution were used to develop the initial elevation grid (Fig. 3.1). LIDAR data, supplied by SARA, were available for some locations. We attempted to use these data where available spatially while filling in the gaps using 10-m DEM data, but the fit using these two data sets was not smooth. Therefore, we used the 10-m DEM data throughout the county.

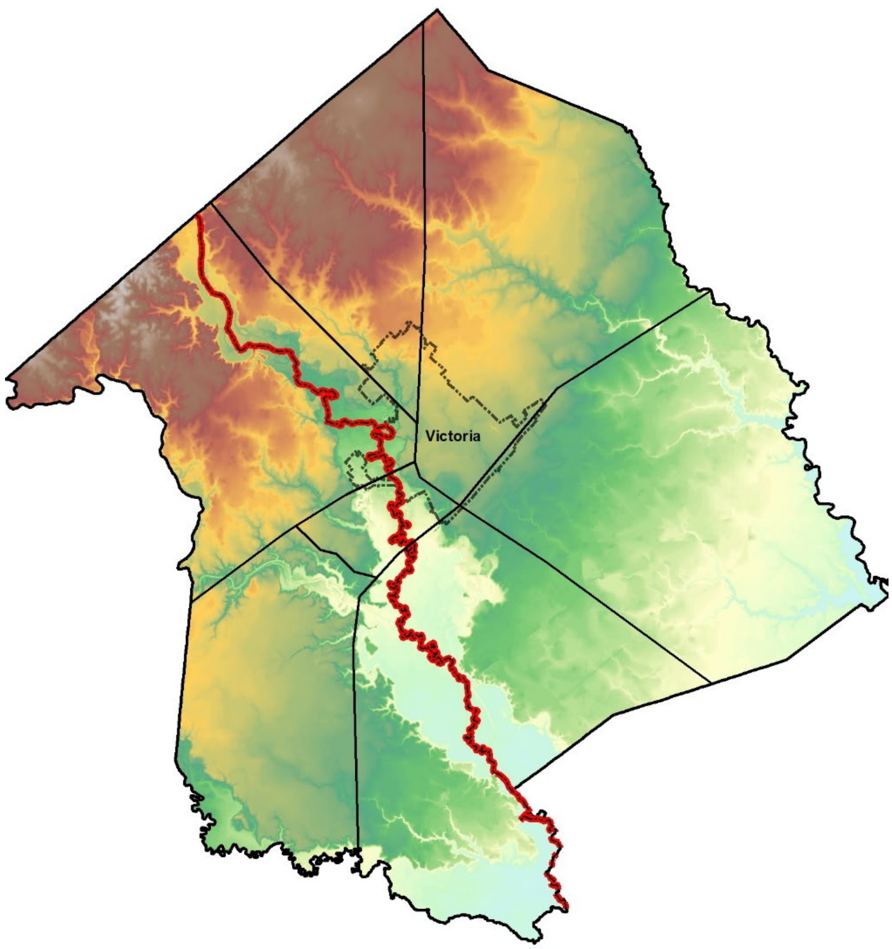


**Figure 3.1 Topographic map of Victoria County based on USGS 10-m DEM data.**

In EDYS, precipitation is applied to each cell. If that cell has the same elevation as all four adjacent cells (i.e., flat topography), there is no runoff, and the water has maximum opportunity for infiltration in the soil profile; the only loss in this case is from evaporation. This condition in EDYS is termed “ponding”. If any of the adjacent cells have lower elevations than the central cell, some water flows from the central cell to the adjacent cells that have lower elevations. The amount of water that flows to the lower cells depends on the infiltration rate of the soil in the central cell, the slope between the central cell and each lower-elevation adjacent cell, and the intensity of the rainfall event. If an adjacent cell has a higher elevation than the central cell, water flows from the higher-elevation cell to the central cell, this amount of water is added to the quantity in the central cell that is available for runoff, and the total amount in excess of infiltration is moved to the adjacent lower-elevation cells. This process continues as a downslope process until all runoff water is moved to the lowest elevation cells or is removed from the spatial footprint (surface flow export).

During a simulation run, elevations can change because of erosion or deposition. This process is discussed in more detail in the soils section (Section 5.0).

## 4.0 PRECIPITATION

Precipitation is an important driving variable for many ecological processes. Both temporal and spatial variations can be ecologically important.

### 4.1 Temporal Variability

Precipitation varies at different time steps, e.g., minute to hourly during a rainfall event, daily, seasonally, annually, and long-term. EDYS inputs precipitation on a daily basis. Use of shorter-term periods (e.g., hourly) is possible in EDYS and can be used in simulations when necessary. The value of precipitation data in simulation modeling, as in most ecological studies, increases substantially as the length of the period of record increases. Long-term (more than 100 years) precipitation data are not available for most recording stations, and the data from most stations are not complete for the reported period of record (i.e., there are missing data). Constructed precipitation data sets (Section 4.3) are used in EDYS models to 1) account for missing data in the recorded data and 2) extend the length of the data set.

Precipitation patterns typically vary on short-, medium-, and long-term scales. Short-term fluctuations include 1) annual variations around a mean, with some years being either drier or wetter than average, and 2) series of below- or above-average precipitation years, the series often lasting 2-5 years but sometimes lasting a decade or more. For example, the long-term (1893-2017) mean annual rainfall recorded at Victoria (excluding years with incomplete data) is 36.65 inches. The driest year on record was 11.15 inches in 1917 (30% of long-term mean), and the wettest year on record was 73.65 inches in 2004 (201% of long-term mean) (Appendix Table A.1). The driest short-term (four continuous years) period on record was 1953-56, during which annual precipitation averaged 21.41 inches (58% of long-term mean), and the wettest short-term (four continuous years) period on record was 2004-07, during which annual precipitation averaged 54.95 inches (150% of long-term mean).

Short-term periodicity at Victoria involves wet-dry cycles (beginning of wet period through end of following dry period) of 4-24 years (average of 13 years) (Fig. 4.1). Above-average (wet) periods within the cycles have an average length of 9.3 years (range = 2-20 years), with average annual means of approximately 39-46 inches (average annual = 42.60 inches). Below-average (dry) periods within the cycles have an average length of 5.3 years (range = 2-12 years), with average annual means of approximately 21-31 inches (average annual = 27.20 inches). There have been eight of these dry-wet cycles since 1899 (a seventh cycle began in 2015) and the average difference in annual rainfall between the dry and wet periods is 15.05 inches (Fig. 4.1).

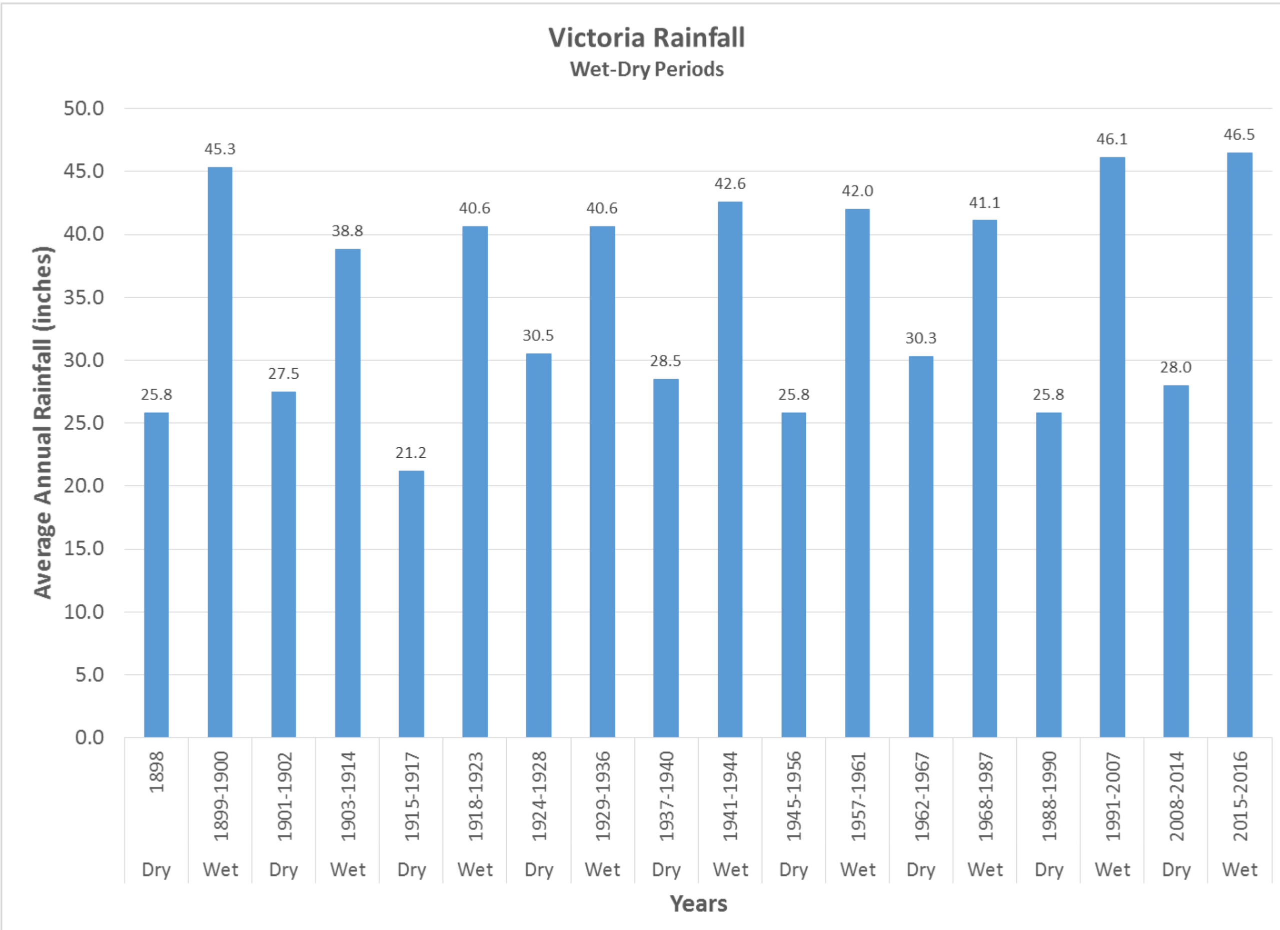


**Figure 4.1 Mean annual precipitation (inches) during eight consecutive wet-dry periods at Victoria, Texas (1898-2016).**

Medium-term changes in precipitation patterns tend to be on the order of 40-60 years and, in the southwestern United States, are correlated with the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation (Cayan et al. 1999; Hidalgo 2004). These multidecadal cycles result in major shifts in rainfall patterns in the Southwest, including southern Texas, that have major impacts on ecological and hydrological systems. For example, average annual rainfall at Victoria during 1901-1956 (56 years) was 33.94 inches (Fig. 4.2). Average annual rainfall during the following 51 years (1957-2007) was 40.66 inches, an increase of 6.7 inches per year (19.8%) for 51 years. This increase in rainfall following the drought of the 1950s is reflected at locations throughout the region (Table 4.1). Over the last nine years (2008-2016), annual rainfall at Victoria has averaged 32.11 inches.

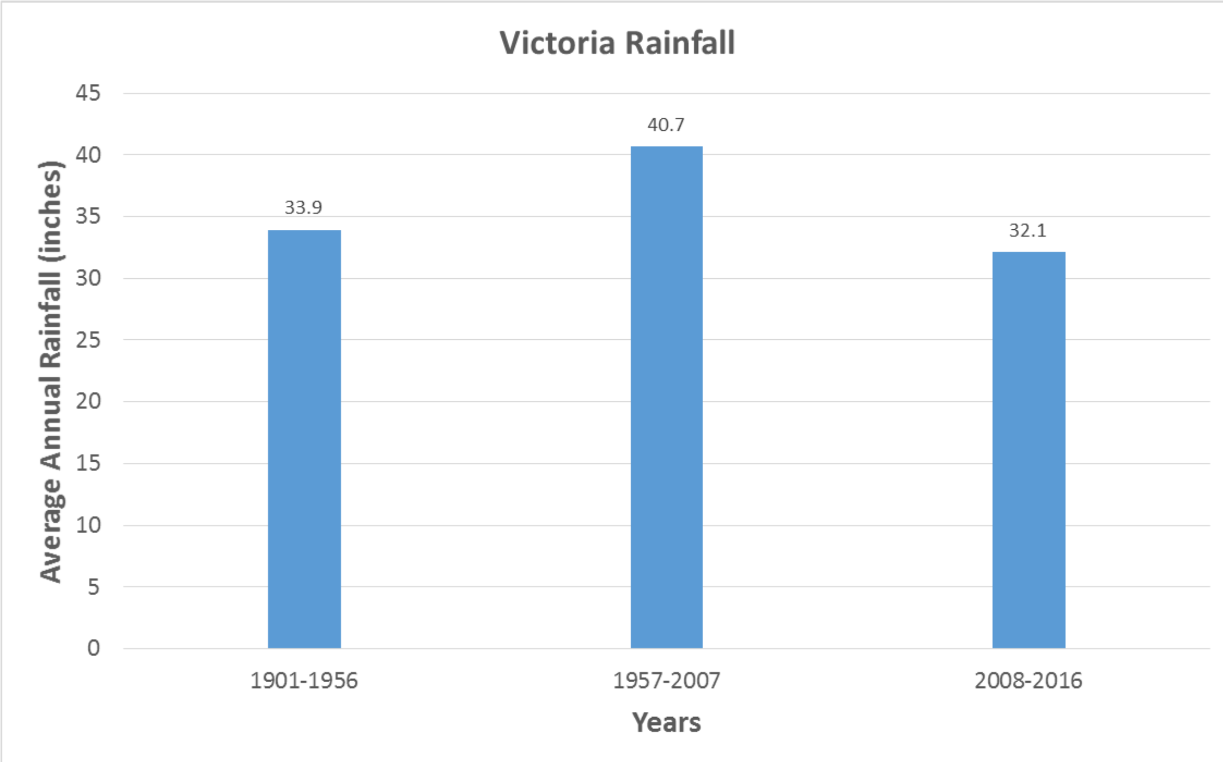


**Figure 4.2 Average annual rainfall (inches) at Victoria, Texas, during two multidecadal periods (1901-1956 and 1957-2007) and the most recent nine years (2008-2016).**

**Table 4.1 Average annual precipitation (PPT; inches) at eight sites in South Texas before the end of the drought of the 1950s and following the drought of the 1950s.**

| Location | Mean PPT | Period | Years[1] | PPT | Period | Years[1] | PPT | After/Before |
|---|---|---|---|---|---|---|---|---|
| Beeville | 31.18 | 1903-1956 | 51 | 31.88 | 1957-2004 | 46 | 33.49 | 1.05 |
| Cuero | 34.48 | 1902-1956 | 54 | 33.98 | 1957-2004 | 39 | 35.93 | 1.06 |
| George West | 27.05 | 1916-1956 | 38 | 26.64 | 1957-2004 | 44 | 28.40 | 1.07 |
| Goliad | 34.82 | 1915-1956 | 42 | 30.91 | 1957-2010 | 54 | 36.00 | 1.16 |
| Runge | 30.25 | 1896-1956 | 48 | 29.09 | 1957-2005 | 48 | 32.29 | 1.11 |
| San Antonio | 29.12 | 1892-1956 | 65 | 26.10 | 1957-2004 | 48 | 32.57 | 1.29 |
| Victoria | 36.65 | 1898-1956 | 56 | 34.20 | 1957-2007 | 51 | 40.66 | 1.20 |
| Mean | | | | | | | | 1.13 |

[1] Years refers to number of years during the period for which there are no missing data.

These medium-length precipitation fluctuations are not confined to arid or semi-arid regions. Humid regions experience similar cycles. Tree-ring data from North Carolina indicate that region has undergone alternating wet-dry cycles of about 30 years each and that 1956-1984 was one of the five wettest periods of the past 1600 years (Stahle et al. 1988). A similar period (1957-1987) was also a wet period for Victoria County (annual mean = 39.14 inches). Oxygen ratios from stalagmites in Belize indicate that major droughts have occurred in the Yucatan at

100-200 year intervals over the past 1800 years and have lasted 50-80 years each occurrence (Kennett et al. 2012).

In addition to these annual and decadal fluctuations, precipitation also changes over longer periods, e.g., centuries and millennia. Climatic patterns may be relatively stable for periods on the order of centuries and then, relatively rapidly (e.g., decades), change sufficiently to cause major vegetation shifts. Much of the western United States underwent a 2000-year period of increasing aridity beginning about 2600 years ago, during which many woodlands in the region decreased in extent and shrublands increased (Tausch et al. 2004). Then, about 650 years ago, the Little Ice Age began, and conditions became much cooler, resulting in an increase in extent of woodlands and wetlands. During that period, vegetation patterns were very different from current patterns (Tausch et al. 2004). Little Ice Age conditions lasted until about 150 years ago when climate shifted again, with aridity again increasing. Much of northwestern Iowa was covered in deciduous forest from 9100-5400 BP, then changed to prairie grassland in 5400-3500 BP, and shifted to oak savanna after 3500 BP (Chumbley et al. 1990). These shifts in vegetation correspond to periods of rapid warming (3° C) followed by cooling (4° C) (Dorale et al. 1992). Nielson (1986) suggested that the black grama (*Bouteloua eriopoda*) grasslands encountered in the northern Chihuahuan Desert 100-150 years ago were a vegetation type established under, and adapted to, 300 years of Little Ice Age conditions and are only marginally supported, and perhaps not likely to be re-established, under present climatic conditions. A similar situation may be true for Victoria County in relation to live oak woodlands (discussed in Section 9.1.1.5).

For 51 years, mean annual rainfall at Victoria was 6.7 inches per year more than in the previous 56 years. That amount of increased rainfall over that long (6.7 inches per year for 51 years) is likely to have resulted in major shifts in vegetation composition and hydrologic yields. Mid- and tallgrass prairie commonly occurs on areas receiving 20-40 inches of rain annually (Weaver and Clements 1938:517; Weaver 1954:7; Shelford 1963:334; Stoddart et al. 1975:28; Smeins and Diamond 1983; Smeins 1994a; Bailey 1995:46). As average annual precipitation increases above about 30 inches per year, tallgrasses begin to replace midgrasses as the dominant vegetation type. Above about 40 inches of annual precipitation, woodlands and forests begin to replace grasslands (Weaver and Clements 1938:510; Engle 1994; Bailey 1995). Stoddart and Smith (1955:48) suggested 38 inches as the upper precipitation limit of the tallgrass prairie. The upper limit on the Coastal Prairies of Texas is about 36 inches (Drawe 1994). In drier environments, sandy soils tend to support woodlands at lower precipitation levels than can be supported on adjacent clay or loam soils.

Average annual rainfall at Victoria was 40.66 inches from 1957-2007. This amount is the approximate level where the vegetation would shift from grassland to woodland, and 51 years is ample time for trees to respond to this increased moisture. Therefore, it is likely that woody vegetation (trees and shrubs) became more abundant in Victoria County following the drought of the 1950s than was present prior to the drought. That increase in deep-rooted woody species (e.g., mesquite, live oak, huisache) would also have probably increased the amount of groundwater use by the vegetation and decreased the amount of potential groundwater recharge. This response to change in woody vegetation is discussed in more detail in Section 9.

## 4.2 Spatial Variability

Precipitation also varies spatially, and these spatial differences can be important in accounting for ecological dynamics across a landscape. In EDYS, precipitation is entered cell by cell across the spatial footprint. Use of precipitation data from a single station may or may not provide realistic estimates of these patterns depending on the magnitude of the change across the spatial domain. Also of importance is the uncertainty associated with making estimates of spatial variability in precipitation patterns.

The primary station used to develop the precipitation file for the Victoria County EDYS model was Victoria. There were two very important factors associated with use of data from this station. First, the Victoria data set is a relatively long-term data set, extending from 1893 through 2016 and containing 116 years of complete 12-month data (Appendix Table A.1). Second, Victoria is located near the center of the county (Fig. 3.1), which makes these data more likely to be representative of the entire county than if the station was located nearer one of the county lines.

In most EDYS applications, the spatial footprint is divided into several precipitation zones to account for at least some of the spatial variation. If there are multiple recording stations located in different parts of footprint, the zones are constructed around each station. When there is only one recording station, as the case for Victoria County, the zones are constructed by finding the mid-points between that one station and the nearest stations in each direction in adjacent locations (counties in this case). The single location data are used for the central portion of the footprint, up to these mid-points. Separate zones are then defined for those areas between the mid-points and the footprint boundaries (county lines in this case) in each direction. This process provides the advantage of accounting for some deviation from the central zone in the outer areas of the footprint but also has several disadvantages (e.g., precipitation values suddenly change when the arbitrary boundary is crossed, uncertainty is entered into the model because of using estimated values).

Only one precipitation zone was used in the Victoria County model, i.e., all cells in the model received the same daily precipitation value, although these values changed daily depending on the record at Victoria. Annual average precipitation in the Coastal Bend area of Texas decreases along a northwest gradient as distance from the Gulf increases and along a southwest gradient once past the first line of counties along the Gulf (Fig. 4.3). However, Victoria County is located in a transition area where these patterns hold in some directions but not in others. For example, moving northwest from Port Lavaca to Cuero, the annual average precipitation at Victoria (36.88 inches) is about half the difference between Port Lavaca (38.33 inches) and Cuero (34.48 inches), and the distances between Victoria and Port Lavaca and between Victoria and Cuero are about the same (28 miles). Based on this relationship, a zone could have been created in southeast Victoria County that would average values between Victoria and Port Lavaca and a zone in northwest Victoria County that would average values between Victoria and Cuero. Unfortunately, the average between Goliad and Edna does not give as good a fit to the data for Victoria, and neither does the average between Halletsville (north) and either Aransas NWR (south) or Refugio (southwest). Because of this lack of fit along this north-south axis, there would be substantial uncertainty how the west and east edges of the northwest zone (Victoria-

Cuero axis) should be treated. Likewise, the lack of fit along the Edna-Refugio (or Edna-Aransas NWR) axis makes the southeast zone (Victoria-Port Lavaca axis) difficult to reasonably estimate. Under such conditions, a single precipitation zone for Victoria County seems reasonable until further analyses of the regional precipitation data can be made.

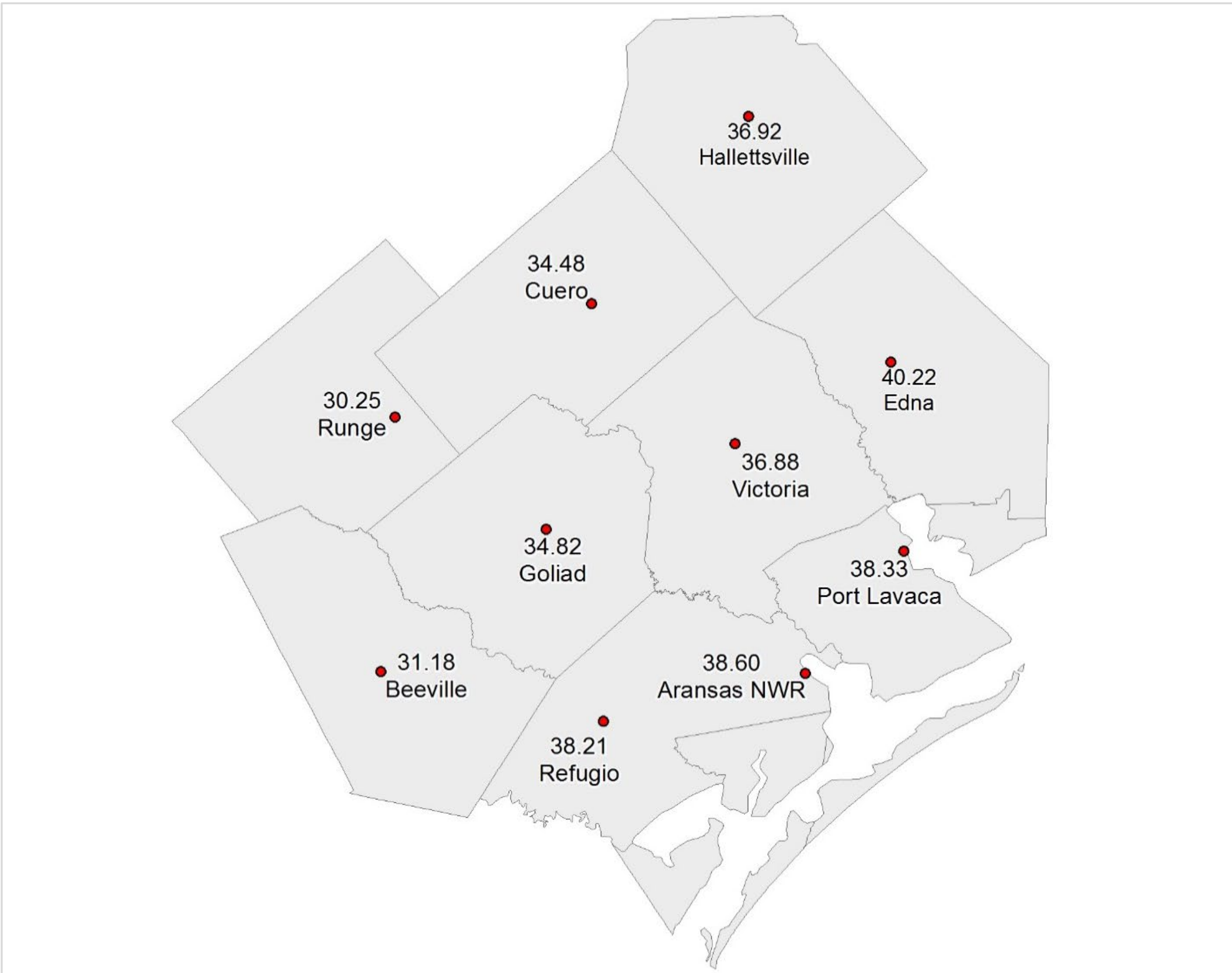


**Figure 4.3 Average annual precipitation (inches) across the Victoria County region. Values are annual means based on recorded data for periods of record at each station. Periods of record and years with complete (12-month) data vary among stations.**

### 4.3 Constructed Precipitation Data Set

The value of precipitation data in simulation modeling, as in most ecological studies, increases substantially as the length of the period of record increases. Long-term (more than 100 years) precipitation data are not available for most stations supplying precipitation data in EDYS applications. However, Victoria does have a relatively long-term data set, and the data set used in the Victoria County EDYS model is based on these data from Victoria, beginning in 1893. Although the Victoria data set is sufficiently long, there are missing values. Of the 122 years included in the period of record used in the model (1893-2014), only 119 have complete data. A constructed precipitation data set was therefore built for Victoria to estimate values for these missing data.

Constructed precipitation data sets are long-term data sets that include recorded data for those dates where these data are available for a particular station plus estimated values for dates where recorded data are not available or where the recorded values are strongly suspect. The estimated values in the constructed precipitation data sets are not presented as precise estimates of the actual amounts received. Instead, they represent reasonable estimates based on the temporal and spatial patterns of the area.

The first step in developing the constructed data set for Victoria County was to determine which nearest stations had precipitation values for any of the dates with missing data for Victoria. For each date with missing data for Victoria, the corresponding value from the nearest station with a reported value for that date was selected. This nearest value was then multiplied by the conversion ratio between Victoria and the respective station. This conversion ratio is the average annual precipitation at the station being estimated divided by the average annual precipitation for the same year at the station being used to estimate, with the averages calculated only using years with complete (12-month) data for years in common between the two stations (Linsley et al. 1982).

Data from three stations were sufficient to provide estimates of the missing Victoria data. These stations, with their corresponding conversion ratios were Goliad (1.061), Cuero (1.058), and Runge (1.212). Victoria had relatively few dates with missing precipitation data. Consequently, most (93.3%, 41,570 days [out of a total of 44,559 days for the 122 years]) of the daily values in the constructed data set were actual recorded values from Victoria. Data from Goliad were used to supply most of the missing values (6.3% of total, 2,807 days), with the remainder from Cuero (0.3% of total, 152 days) and Runge (0.1% of total, 30 days).

Annual values used in the constructed precipitation data set for the Victoria County EDYS model are presented in Table 4.2. Although only annual precipitation values are presented in Table 4.2, the precipitation input data used in EDYS are daily values.

**Table 4.2 Long-term (122 years) constructed annual precipitation data (PPT; inches) used in the Victoria County EDYS model.**

| Year | PPT | Year | PPT | Year | PPT | Year | PPT | Year | PPT | Year | PPT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1893 | 17.78 |
| | | | | | | | | | | 1894 | 28.12 |
| | | | | | | | | | | 1895 | 26.31 |
| | | | | | | | | | | 1896 | 25.93 |
| | | | | | | | | | | 1897 | 12.15 |
| | | | | | | | | | | 1898 | 25.75 |
| | | | | | | | | | | 1899 | 36.86 |
| | | | | | | | | | | **MEAN** | **24.70** |
| 1900 | 59.53 | 1910 | 30.22 | 1920 | 28.97 | 1930 | 36.84 | 1940 | 35.65 | 1950 | 18.65 |
| 1901 | 23.00 | 1911 | 36.42 | 1921 | 41.79 | 1931 | 44.30 | 1941 | 51.00 | 1951 | 37.44 |
| 1902 | 32.00 | 1912 | 25.45 | 1922 | 33.92 | 1932 | 30.32 | 1942 | 38.32 | 1952 | 37.15 |
| 1903 | 55.74 | 1913 | 43.77 | 1923 | 44.65 | 1933 | 35.16 | 1943 | 37.54 | 1953 | 29.30 |
| 1904 | 35.31 | 1914 | 53.50 | 1924 | 29.52 | 1934 | 38.54 | 1944 | 43.46 | 1954 | 23.73 |
| 1905 | 45.30 | 1915 | 25.73 | 1925 | 27.14 | 1935 | 37.28 | 1945 | 27.04 | 1955 | 30.33 |
| 1906 | 26.99 | 1916 | 26.57 | 1926 | 40.99 | 1936 | 46.67 | 1946 | 34.45 | 1956 | 14.32 |
| 1907 | 43.98 | 1917 | 11.15 | 1927 | 24.41 | 1937 | 25.51 | 1947 | 22.49 | 1957 | 42.43 |
| 1908 | 40.17 | 1918 | 36.36 | 1928 | 30.57 | 1938 | 32.24 | 1948 | 19.89 | 1958 | 36.42 |
| 1909 | 34.38 | 1919 | 59.53 | 1929 | 51.76 | 1939 | 20.57 | 1949 | 35.12 | 1959 | 32.31 |
| **MEAN** | **39.64** | **MEAN** | **34.87** | **MEAN** | **35.37** | **MEAN** | **34.74** | **MEAN** | **34.50** | **MEAN** | **30.21** |
| 1960 | 48.17 | 1970 | 39.76 | 1980 | 32.52 | 1990 | 36.78 | 2000 | 36.65 | 2010 | 46.58 |
| 1961 | 35.62 | 1971 | 36.04 | 1981 | 45.07 | 1991 | 60.07 | 2001 | 41.98 | 2011 | 13.08 |
| 1962 | 25.89 | 1972 | 42.39 | 1982 | 32.49 | 1992 | 58.40 | 2002 | 41.10 | 2012 | 28.13 |
| 1963 | 22.05 | 1973 | 45.62 | 1983 | 42.38 | 1993 | 54.82 | 2003 | 37.57 | 2013 | 25.56 |
| 1964 | 33.30 | 1974 | 43.32 | 1984 | 33.92 | 1994 | 43.16 | 2004 | 73.60 | 2014 | 33.26 |
| 1965 | 30.85 | 1975 | 36.95 | 1985 | 39.96 | 1995 | 37.67 | 2005 | 34.93 | | |
| 1966 | 35.44 | 1976 | 43.25 | 1986 | 39.17 | 1996 | 27.89 | 2006 | 39.41 | | |
| 1967 | 33.88 | 1977 | 39.19 | 1987 | 43.08 | 1997 | 64.99 | 2007 | 71.73 | | |
| 1968 | 49.29 | 1978 | 43.04 | 1988 | 16.16 | 1998 | 42.67 | 2008 | 21.71 | | |
| 1969 | 44.61 | 1979 | 49.28 | 1989 | 26.25 | 1999 | 30.36 | 2009 | 30.78 | | |
| **MEAN** | **35.91** | **MEAN** | **41.88** | **MEAN** | **35.10** | **MEAN** | **45.68** | **MEAN** | **42.95** | **MEAN** | **29.31** |

Overall mean (1893-2014) = 36.29 inches

## 5.0 SOILS

Two soil components are included in an EDYS model. First, a soils map is constructed that indicates the spatial location of each soil unit (soil series or soil type) included in the spatial footprint of the model. Second, profile descriptions are developed for each of the soil units.

### 5.1 Soils Map

A total of 49 soil units, excluding water and extensively disturbed sites, are defined and mapped by the Natural Resource Conservation Service (NRCS) as occurring in Victoria County (Miller 1982). Many of these are subdivisions of soil series based on differences in slope, frequency of flooding, or thickness of an upper soil horizon. For example, the soil unit DaA is Dacosta sandy clay loam, 0-1% slope, while DaB is Dacosta sandy clay loam, 1-3% slope, To is Trinity clay, occasionally flooded, and Tr is Trinity clay, frequently flooded. As such, these differences likely have little significance in affecting ecological responses because slope and frequency of flooding are accounted for in EDYS based on topography and location of the cell. Lack of ecological significance among soils differering only in slope and flooding frequency is also attested to by the fact that most of the subdivisions have the same assigned ecological site (Miller 1982).

In order to keep the number of cell types in the Victoria County EDYS model within practical limits, similar soil units were combined. The primary criterion used was whether or not the differences between the soil units were likely to result in measurable and ecologically significant differences in vegetation, hydrology, or management responses. Based on this criterion, the 49 soil units were reduced to 19 soil types (Table 5.1). This set of 19 soil types provided a unique soil to be assigned to each NRCS ecological site, with the exception of the Sandy Loam type that had two soil types assigned to it.

**Table 5.1 Soil types included in the Victoria County EDYS model, along with their corresponding ecological site types.**

| Musym | Soil Type | Surface Texture | Surface Horizon Depth (inches) | Ecological Site |
|---|---|---|---|---|
| Ar | Aransas | clay | 11 | Salty Bottomland |
| DxB | Denhawken-Elmendorf | clay loam | 5 | Rolling Blackland |
| FoB | Fordtran | loamy fine sand | 28 | Sandy Prairie |
| InB | Inez | fine sandy loam | 8 | Sandy Loam |
| KyC | Kuy | loamy sand | 6 | Deep Sand |
| LaA | Lake Charles | clay | 46 | Blackland |
| LmB | Leming | loamy fine sand | 29 | Loamy Sand |
| Me | Meguin | silty clay | 10 | Loamy Bottomland |
| NcA | Nada-Cieno | sandy loam | 8 | Claypan Prairie |
| PaB | Papalote | fine sandy loam | 16 | Tight Sandy Loam |
| Pe | Placedo | silty clay loam | 12 | Salt Marsh |
| RaC | Runge | fine sandy loam | 9 | Sandy Loam |
| SaB | Sarnosa | loam | 13 | Gray Sandy Loam |
| TeA | Telferner | fine sandy loam | 10 | Loamy Prairie |
| TgC | Tremona | gravelly loamy sand | 10 | Gravelly |
| Tr | Trinity | clay | 20 | Clayey Bottomland |
| VaD | Valco | clay loam | 10 | Shallow |
| WeC | Weesatche | sandy clay loam | 7 | Clay Loam |
| Za | Zalco | sand | 4 | Sandy Bottomland |

The NRCS mapped soil units were displayed on an aerial photograph (Fig. 5.1) and each 40 m x 40 m EDYS cell was then assigned one of the 49 original soil units based on the location of the cell in relation to the spatial locations of the soil units. This 49-unit classification was then converted to the 19-type (Table 5.1) classification by combining units as appropriate.

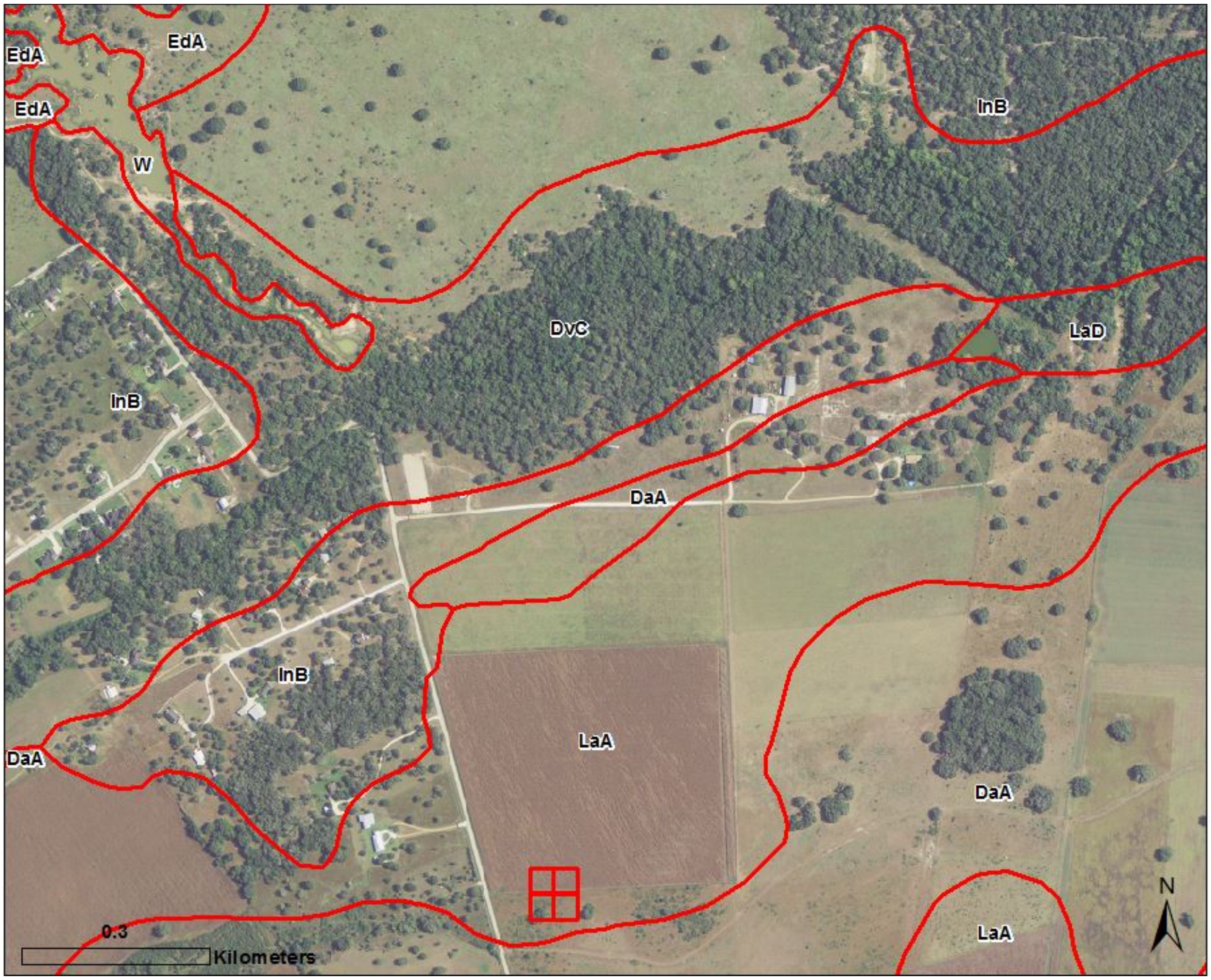


**Figure 5.1 Example of the spatial distribution of NRCS soil units on a portion of the Victoria County landscape. The four red squares in the lower portion represent 40 m x 40 m cells in EDYS.**

## 5.2 Profile Descriptions

A soil profile is a vertical section of a particular soil. Soils are composed of layers, called horizons, with each horizon differing in some major physical or chemical variable from the layer above and the layer below it. Horizons are designated by capital letters (e.g., A, B, C) in a top-down order. Horizons are often subdivided, and these subdivisions are designated by lower-case letters (e.g., Ap, Bk, Bt) with the letters referring to specific types of soil conditions, and/or numbers (e.g., A1, A2, Bt1, Bt2) designating vertical order within the horizon (capital letter). General profile descriptions of each soil occurring in a particular county are provided in the NRCS Soil Survey for that county. The Lake Charles clay, the soil covering the most area in Victoria County, is presented as an example (Table 5.2).

**Table 5.2 NRCS profile description of the Lake Charles clay (Miller 1984).**

| Horizon | Depth (cm) | Texture | Color | Structure | Alkalinity |
|---|---|---|---|---|---|
| A11 | 000-028 | clay | black | moderate subangular blocky | neutral |
| A12 | 028-058 | clay | black | moderate subangular blocky | neutral |
| A13 | 058-115 | clay | very dark gray | moderate subangular blocky | moderate |
| AC | 115-135 | clay | dark gray | weak angular blocky | moderate |
| C | 135-203 | clay | pale brown | massive | moderate |

EDYS soil profiles are based on the NRCS profiles but differ in two primary ways. First, EDYS profiles contain more layers and extend to greater depths than their respective NRCS profiles. The usual time step in EDYS simulations is daily. Daily changes in belowground processes that affect plant growth (e.g., available soil moisture, root growth, availability of soil nutrients) occur at finer spatial scales (soil depths) than those designated for NRCS soil horizons. For example, many precipitation events supply only small amounts of water. The median summer rainfall event in many drier regions is less than 5 mm (Schwinning and Sala 2004). In many soils, a 5-mm rainfall event will supply water to only the top 5 cm (2 inches) of the soil, and at that depth most of the rainfall-supplied water will be extracted by evaporation before it can be used by plants in transpiration. In contrast, a 10-mm rainfall event on the same soil might supply some moisture to a depth of 10 cm or more, and at that depth some of the water would be extracted by evaporation and some by transpiration. Only that water used in transpiration would be available to support plant growth. Therefore, small differences in soil depth can substantially affect plant growth responses. For this reason, thinner soil layers are used in EDYS.

The number of soil layers is flexible in EDYS, but commonly 35 layers are used per soil. This approach is the case for the Victoria County model. Although there are 35 soil layers in each of these EDYS soil profiles, the thickness (depth) and characteristics of each layer vary among soils. EDYS soil layers are subdivisions of NRCS horizons and subhorizons, with each NRCS horizon or subhorizon divided into one or more EDYS layers. However, no EDYS layer combines parts of more than one NRCS horizon or subhorizon. For example, no EDYS layer would include the 025-030 cm depth of the Lake Charles clay (Table 5.2) because that would combine different horizons (lower part of A11 and upper part of A12). There could, however, be EDYS horizons of 020-028 cm and 028-035 cm because the first would be from the A11 horizon and the second from the A12 horizon.

NRCS profile descriptions do not include subsoil material. Most NRCS profiles extend to only 203 cm (80 inches). EDYS profiles extend much deeper, with the lower depth based on the maximum potential rooting depth of the deepest-rooted plant species included in the particular EDYS application (Appendix Table E.9). These deeper depths are included in EDYS because plant roots extend into these zones, and those zones contain moisture and nutrients that can be accessed by the plants. The thickness and other characteristics of the lower EDYS soil layers are estimated from parent material information provided in the NRCS soil surveys and from other literature sources. These lower EDYS layers are thicker than the upper soil layers because daily changes in moisture inputs and root dynamics are not as dynamic as those in the upper layers and because less information is available about the characteristics of the lower layers.

The second primary way in which EDYS profiles differ from NRCS profiles is that some soil variables are included in the EDYS profiles that are not included in the NRCS profiles, and some NRCS soil variables are not included in the EDYS profiles. Variables included in the NRCS profiles are largely descriptive variables, i.e., those useful in classifying soils. Variables included in EDYS profiles are functional variables, i.e., variables that affect ecological processes. For example, soil color is a major classification variable in NRCS profile descriptions (Table 5.2), but soil color has little direct impact on ecological or hydrological responses and is therefore not included in EDYS profiles. Conversely, total available moisture content is an important variable influencing plant growth but is not useful in classifying a soil because it changes rapidly and frequently. Hence, it is included in EDYS profile descriptions but not in NRCS profile descriptions. Data used to provide values for the EDYS soil variables are taken from NRCS soil surveys, other literature sources, and estimates based on existing information.

Eleven soil variables are included, by soil layer, for each EDYS soil profile (Table 5.3). EDYS simulates belowground dynamics based on these 11 variables and the changes in their values that occur during a simulation. Five variables (soil texture, bulk density, maximum moisture content at saturation, field moisture capacity level, and permanent wilting moisture level) remain constant during a simulation. Five variables (moisture content, nutrient content, organic matter content, salinity levels, and contents of any contaminants) change during a simulation as resources enter or exit the various soil layers. Thickness of each layer remains constant unless erosion or deposition occurs. If deposition occurs, the thickness of the top layer increases by the corresponding amount. If erosion occurs, the thickness of the top layer decreases by the corresponding amount. If erosion is sufficient to remove all the top layer, then the process shifts to the second layer, and this process continues as long as erosion continues.

**Table 5.3 Soil variables used in EDYS simulations.**

| Variable | Unit | Comment |
|---|---|---|
| Layer thickness | cm | Initial values entered as inputs. |
| Soil texture (sand, silt, clay) | % | Not directly used as an input variable. Used to calculate soil water holding capacities and infiltration and percolation rates. |
| Bulk density | $g/cm^3$ | Not directly used as an input variable. Used to calculate pore space. |
| Maximum moisture content at saturation | g/layer | Calculated from (pore space – organic matter content). |
| Field capacity level | g/layer | Calculated from soil texture unless specific laboratory data are available. |
| Permanent wilting level | g/layer | Calculated from soil texture unless specific laboratory data are available. |
| Available moisture content | g/layer | Calculated: (amount of water in layer – amount held at permanent wilting) |
| Nutrient levels (e.g., N, P) | g/layer | Initial values entered as inputs. |
| Organic matter content | g/layer | Initial values entered as inputs. |
| Salinity levels | ppm | Initial values entered as inputs. |
| Contaminant levels | ppm | Initial values entered as inputs. |

Water is the major factor controlling belowground dynamics. Terrestrial plants uptake the water they need for maintenance and growth from the soil (including groundwater in the subsoil). The location (depth) of water stored in the soil (i.e., soil moisture) in relation to root architecture of the various plant species is an important factor controlling the competition among the species.

Nutrients and contaminants become available for plant uptake as they enter into soil solution and their concentrations vary as amounts are moved among layers by water movement. Organic matter is also moved among layers by water movement, and the decomposition and mineralization rates of organic matter are controlled, in part, by the moisture content of the soil.

In EDYS, water can arrive at the surface of a spatial cell in two ways, by a precipitation event and by surface movement from a surrounding cell (i.e., run-on). Some of this water can enter the soil profile (infiltration) and some exits the cell as runoff. Litter on the soil surface has the first opportunity for absorption of water in EDYS. If litter is present and is at less than its maximum moisture content, it can absorb sufficient water to bring it up to maximum moisture content. The remaining water is available for infiltration into the soil profile and runoff from the cell.

In EDYS, the amount of water that can potentially enter into the soil profile during a rainfall event is modeled as a step function. The amount of rain in each rainfall event is divided into five parts (10%, 20%, 40%, 20%, and 10% of the total amount). The amount of water in Step 1 (10% of the rainfall event) is compared to the available storage capacity (saturation capacity minus current moisture content) of the first layer. If the amount of water is less than or equal to the available storage capacity, all that quantity of water (10% of the event) is moved into the first layer. If the amount is in excess of available storage capacity, the excess amount is moved to adjacent cells as runoff. This process is repeated through each of the next four steps, with the number of layers used to calculate available storage capacity increasing by one layer at each step (e.g., Step 3 = 40% of rainfall event compared to available storage capacity of top three layers).

Once water moves into a soil layer it is moved downward using a "tipping bucket" algorithm. Any water in excess of field capacity of the first layer moves into the second layer. Any water in excess of field capacity of the second layer is moved into the third layer. This process continues in a top-down manner until the amount of water is stored in the various soil layers, or if some remains once the wetting front reaches saturated soil (groundwater), the surplus amount is added to groundwater. If the groundwater is unconstrained (i.e., groundwater lateral flow can occur), this amount of added water is removed as "export". If the groundwater is constrained, then the water content of the layer immediately above the saturated layer increases above field capacity. This increase can continue until the saturation level is reached for that entire layer, at which time the process continues in an upward manner into the next unsaturated layer.

As water moves downward by percolation, soluble materials (nutrients, contaminants, and organic matter) are moved with the water. As water moves into the next layer at each time step, the concentrations of the soluable materials in that layer are recalculated based on the amount of those materials in the layer prior to entry of the new water and the new concentration resulting from all the surplus water (not just field capacity) that at least temporarily moves into that layer. If some water then continues to move downward out of that layer, that water transports with it the amount of nutrients, contaminants, and organic matter corresponding to its relative concentration.

Soil water (including groundwater) is extracted from each layer at each time step by plant uptake (transpiration). The amount removed from each layer is determined by the amount of roots of each plant species in that layer, the depth of the layer (root uptake is modeled as a top-down process), and the amount of water transpired by each species. Soil water can also be extracted by evaporation. However, evaporation occurs directly only from the surface soil layer. Stored soil moisture can be moved from a maximum of the next three soil layers upward to the surface soil layer and then lost by evaporation, but this process is time-step controlled, and plant roots get first priority use of the water as it moves upward from the second, third, and fourth layers.

In addition to movement by water, organic matter can be added to a soil layer by death of plant material (roots) in that particular layer and by some movement of surface litter into the upper soil layer. The deposition of this material is based on root death rates specific to each plant species and decomposition rates that are influenced by moisture content and nitrogen availability.

## 6.0 VEGETATION

### 6.1 Plant Species

The number of plant species included in a specific EDYS application is flexible. How many and which species are included depends on the requirements of the application and the level of complexity desired. The inclusion of more species increases the potential for the model to simulate the complexity common to most landscapes, but it also increases run times and memory requirements.

The EDYS data base includes ecological data on over 250 species, not all of which occur in Victoria County, and not all of which have data for all plant parameter variables used in EDYS. In each EDYS application, only the subset of species occurring in the spatial domain is used. Several factors are considered in the selection of this subset.

- The subset should include the major species of the area, based on both ecological and management importance. Ecological importance includes dominant and sub-dominant species for each of the included plant communities, as well as successionally important species and threatened and endangered species if they are present.
- There must be sufficient ecological data available for the included species such that the required parameter variable values can be determined or reasonably estimated. Data for all parameter variables may not be available for a major species. In such cases, reasonable estimates can often be made based on available data for closely-related or ecologically similar species.
- For species that require a substantial amount of their parameter values to be estimated, care must be taken that those estimates are not based largely on data from species selected to estimate values for other included species. Otherwise, little new information is actually included in the model by adding another species.
- The inclusion of the species should be expected to sufficiently increase the ability of the model to simulate ecological responses to justify any associated increase in run time, memory requirements, or time required to interpret results.
- The inclusion of the species should not unduly increase unaccounted error (i.e., "noise") into the model output.

Based on these factors, 66 plant species are included in the Victoria County model (Table 6.1).

**Table 6.1 Plant species included in the Victoria County EDYS model.**

| Lifeform | Scientific Name | Common Name |
|---|---|---|
| Tree | *Acacia farnesiana* | huisache |
| Tree | *Carya illinioensis* | pecan |
| Tree | *Celtis laevigata* | sugar hackberry |
| Tree | *Prosopis glandulosa* | mesquite |
| Tree | *Quercus stellata* | post oak |
| Tree | *Quercus virginiana* | live oak |
| | | |
| Shrub | *Acacia rigidula* | blackbrush |
| Shrub | *Baccharis texana* | prairie baccharis |
| Shrub | *Borrichia frutescens* | sea oxeye |
| Shrub | *Celtis pallida* | granjeno |
| Shrub | *Rosa bracteata* | Macartney rose |
| Shrub | *Sesbania drummondii* | rattlepod |
| | | |
| Vine | *Smilax bona-nox* | greenbriar |
| Vine | *Vitis mustangensis* | mustang grape |
| | | |
| Perennial grass | *Andropogon gerardii* | big bluestem |
| Perennial grass | *Andropogon glomeratus* | bushy bluestem |
| Perennial grass | *Aristida purpurea* | purple threeawn |
| Perennial grass | *Aristida purpurescens* | arrowfeather threeawn |
| Perennial grass | *Bothriochloa saccharoides* | silver bluestem |
| Perennial grass | *Bouteloua curtipendula* | sideoats grama |
| Perennial grass | *Buchloe dactyloides* | buffalograss |
| Perennial grass | *Cenchrus incertus* | sandbur |
| Perennial grass | *Chloris cucullata* | hooded windmillgrass |
| Perennial grass | *Cynodon dactylon* | bermudagrass |
| Perennial grass | *Distichlis spicata* | saltgrass |
| Perennial grass | *Elymus virginicus* | Virginia wildrye |
| Perennial grass | *Elyonurus tripsacoides* | Pan-american balsamscale |
| Perennial grass | *Eragrostis intermedia* | Plains lovegrass |
| Perennial grass | *Panicum virgatum* | switchgrass |
| Perennial grass | *Paspalum lividum* | longtom |
| Perennial grass | *Paspalum plicatulum* | brownseed paspalum |
| Perennial grass | *Paspalum setaceum* | thin paspalum |
| Perennial grass | *Phragmites australis* | common reed |
| Perennial grass | *Schizachyrium scoparium* | little bluestem |
| Perennial grass | *Setaria geniculata* | knotroot bristlegrass |
| Perennial grass | *Setaria leucopila* | plains bristlegrass |
| Perennial grass | *Sorghastrum nutans* | indiangrass |
| Perennial grass | *Sorghum halepense* | Johnsongrass |
| Perennial grass | *Spartina spartinae* | gulf cordgrass |
| Perennial grass | *Sporobolus asper* | tall dropseed |
| Perennial grass | *Stipa leucotricha* | Texas wintergrass |

**Table 6.1 (Cont.)**

| Lifeform | Scientific Name | Common Name |
|---|---|---|
| Perennial grass | *Sporobolus indicus* | smutgrass |
| Annual grass | *Sorghum bicolor* | milo |
| Grass-like | *Carex microdonta* | littletooth sedge |
| Grass-like | *Cyperus odoratus* | flatsedge |
| Grass-like | *Scirpus americanus* | Olney bulrush |
| Grass-like | *Typha latifolia* | cattail |
| Perennial forb | *Ambrosia psilostachya* | ragweed |
| Perennial forb | *Aster spinosus* | spiny aster |
| Perennial forb | *Baptistia leucophaea* | wild indigo |
| Perennial forb | *Clematis drummondii* | old-mans beard |
| Perennial forb | *Desmanthus velutinus* | bundleflower |
| Perennial forb | *Eupatorium odoratum* | mistflower |
| Perennial forb | *Heterotheca subaxillaris* | camphorweed |
| Perennial forb | *Phyla nodiflora* | frogfruit |
| Perennial forb | *Rhynchosia americana* | snoutbean |
| Perennial forb | *Ruellia nodiflora* | ruellia |
| Perennial forb | *Salicornia virginica* | glasswort |
| Perennial forb | *Simsia calva* | bush sunflower |
| Perennial forb | *Zexmenia hispida* | orange zexmenia |
| Annual forb | *Ambrosia trifida* | giant ragweed |
| Annual forb | *Amphiachyris dracunculoides* | annual broomweed |
| Annual forb | *Chamaecrista fasciculata* | partridge pea |
| Annual forb | *Croton texensis* | Texas doveweed |
| Annual forb | *Helianthus annuus* | sunflower |
| Annual forb | *Iva annua* | sumpweed |

## 6.2 Vegetation Formations

A vegetation formation is a subdivision of a biome (McLendon 1991), with the subdivision based on either a general environmental factor (e.g., sandy prairie, riparian woodland) or the dominant genus or species (e.g., oak woodland). Fourteen major vegetation formations occur in Victoria County (Table 6.2), with several to numerous plant communities in each formation.

**Table 6.2 Major vegetation formations in Victoria County, Texas.**

| Woodlands | Shrublands | Grasslands | Aquatic | Agricultual |
|---|---|---|---|---|
| Huisache woodlands | Macartney rose shrublands | Clay/clay loam prairies | Lakes/ponds | Cultivated |
| Mesquite woodlands | Mesquite shrublands | Sand prairies | River/creeks | Pasture |
| Oak woodlands | Xeric shrublands | Cordgrass flats | | |
| Riparian woodlands | | | | |

### 6.2.1 Woodlands

Riparian woodlands occur along the banks of the Guadalupe and San Antonio Rivers and banks of the larger creeks. These woodlands commonly have a continuous or nearly continuous canopy cover of trees. The trees tend to be medium-sized to large and of mixed composition. The width of the community generally increases as the size and flow of the associated drainage increases. This bottomland community can extend outward 100-200 m or more from each bank of the Guadalupe and San Antonio Rivers in some areas, or be as narrow as 10-20 m along some areas of the mid-sized creeks.

Huisache (*Acacia farnesiana*) is a small- to medium-sized tree that can form dense stands on frequently flooded sites, recently disturbed areas, and grassland sites (both native and pasture). It is an aggressive, mid-seral colonizer. Huisache is particularly well-adapted to relatively wet sites, where the surface is frequently flooded and the water table is near the surface. However, it also forms extensive, but less dense, stands on drier sites. On drier, especially clay loam, sites huisache has a competitive advantage over mesquite (*Prosopis glandulosa*) earlier in succession, but mesquite tends to have the competitive advantage over time.

In Victoria County, mesquite woodlands are particularly well-developed on clay loam sites with relatively deep soils that are not frequently flooded. Mesquite woodlands often occur as strips along the drier edges of the riparian woodlands and along the edges of oak woodlands. In these areas, the mesquite can become large (1-m diameter trunks) and form nearly continuous canopies. Many former grassland sites now support mesquite woodland, in part because of long-term overgrazing by livestock.

Oak woodlands occur on sites where the soils are moderate to deep sands, sandy loams, or sandy clays. Some oak, especially live oak (*Quercus virginiana*), are common components of the riparian woodlands. As the soils become sandier, oaks also tend to become the dominant species on wooded upland sites. Post oak (*Q. stellata*) woodlands tend to form somewhat continuous stands across the landscape, while live oak woodlands tend to form mottes, some of which can be extensive. However, both species can occur in relatively extensive stands or in large clusters.

### 6.2.2 Shrublands

There are three primary shrubland formations in Victoria County: Macartney rose shrublands, mesquite shrublands, and xeric shrublands. Macartney rose (*Rosa bracteata*) is a non-native species that was introduced on the Texas Coastal Prairies in the late 1800s as a “living fence”. Since then, it has expanded onto grasslands and edges of woodlands, forming dense thickets up to 3 m tall that exclude most other plant species beneath the rose canopies. As the species begins to invade a site, the initial plants are small and occur in scattered locations. Over time, these individuals increase in size to form dense clusters. Eventually, the species can form dense canopies covering 90-100% of the area. Macartney rose is particularly well-adapted to frequently flooded clay and clay loam sites. The species was estimated to occur on about 320,000 acres in the Texas Coastal Prairies in 1975 (Scifres 1975). By 1990, this total increased to 500,000 acres (Meyer and Bovey 1990), or an increase of about 54% in 15 years.

Mesquite shrublands occur mostly on clay and loam sites that are either drier than those supporting mesquite woodlands or have been more recently or more frequently disturbed. The drier nature of these sites generally occurs because there is a deeper water table than on soils supporting mesquite woodlands. The mesquite on these shrubland sites tend to be smaller than those in the woodlands, although they can obtain tree size (e.g., 3-8 m tall). Shrubs of various species are frequent in this formation.

The xeric shrublands occur mostly on shallow limestone (caliche) sites. These sites are scattered throughout the county but are most common in the northern and western parts. The soils are thin (5-40 cm) over a generally fractured limestone substrate, the upper portion of which varies between somewhat soft to dense indurated caliche. The vegetation on these sites tends to be short (2-4 m tall) dense shrublands. Blackbrush (*Acacia rigidula*) is the most common dominant and often occurs as very dense, almost monoculture, stands with little understory (Dodd and Holtz 1972; McLendon 1991). Numerous other xeric shrubs occur in this formation, along with small scattered mesquite.

### 6.2.3 Grasslands

Native grasslands were probably more extensive in Victoria County in the past, but cultivation, conversion to improved pastures, and increases in woody species have reduced their extent. There is relatively little area in native clay or clay loam grasslands remaining. In the past, these grasslands were concentrated in the southern half of the county. Those that do currently exist have mostly been restored, either from previously cultivated land or from brush control. These clay/clay loam grasslands were midgrass prairie, dominated mostly by silver bluestem (*Bothriochloa saccharoides*) and little bluestem (*Schizachyrium scoparium*), with substantial amounts of other midgrass species such as sideoats grama (*Bouteloua curtipendula*), trichloris (*Chloris pluriflora*), plains bristlegrass (*Setaria leucopila*), Arizona cottontop (*Digitaria californica*), and Texas cupgrass (*Eriochloa sericea*). More mesic sites such as low-lying areas and ecotones to the riparian woodlands also contained large amounts of tallgrasses such as big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and eastern gamagrass (*Tripsacum dactyloides*). The non-natives Johnsongrass (*Sorghum halepense*) and guineagrass (*Panicum maximum*) are now abundant on many of these sites.

Sand prairies in Victoria County have also been reduced in area over time, occurring mostly as large openings in the oak woodlands in northern part of the county and a large area (McFaddin Prairie) in the southwest part of the county. The sand prairies are also midgrass prairies, typically dominated by little bluestem (in the north), seacoast bluestem (*Schizachyrium* *scoparium* var. *littoralis*; in the south), and tall dropseed (*Sporobolus asper*). Other important midgrasses are arrowfeather threeawn (*Aristida purpurescens*), Pan-American balsamscale (*Elyonurus tripsacoides*), tanglehead (*Heteropogon contortus*), brownseed paspalum (*Paspalum plicatulum*), and thin paspalum (*P. setaceum*). Forbs are common in these prairies and, when moisture is sufficient, extensive stands of bluebonnets (*Lupinus texensis*), Indian paintbrush (*Castilleja indivisa*), coreopsis (*Coreopsis tinctoria*), and Indian blanket (*Gaillardia pulchella*) can be spectacular.

Cordgrass flats occur in the southern part of Victoria County in a transition zone between the upland plant communities and coastal wetland communities. Gulf cordgrass (*Spartina spartinae*) is the dominant species, generally forming dense tussock grasslands. The sites are seasonally-flooded sites, or infrequently-flooded sites, where the water is brackish and the soils saline. Gulf cordgrass often forms almost mono-specific stands, with tussocks 1-1.5 m tall and canopy cover ranging from less than 50% to almost 100%. The stands can occur as relatively small stands (1 hectare or less) or as extensive flats covering 200 hectares (500 acres) or more.

### 6.2.4 Aquatic Systems

There are two major lakes in Victoria County, the Coleto Creek Reservoir along the western edge of the county and Linn Lake in the south. There are abundant ponds and small lakes, mostly man-made, throughout the county. The vegetation associated with these, including stock tanks, varies by size, depth, and perennial water-holding capability of the pond or lake, but is typical of this type of wetland vegetation in the region. There is commonly an open water surface with little emergent or surface vegetation. As water depth decreases, floating species may occur if the pond has permanent water. Next is a zone of emergent vegetation, typically cattails (*Typha* spp.) and bulrushes (*Scirpus* spp.), then a zone of wetland species including cutgrass (*Leersia hexandra*), sedges (*Carex* spp.), spikerushes (*Eleocharis* spp.), flatsedges (*Cyperus* spp.), longtom (*Paspalum lividum*), and rattlepod (*Sesbania drummondii*). These zones can be narrow (25-50 cm) or wider (e.g., 10 m) depending on the size, structure, and permanency of the pond. Heavy use by livestock often reduces the size and diversity of these zones.

The Guadalupe River flows through the center of the county and the San Antonio River forms part of the south boundary of the county. There are numerous small to medium-sized creeks, in particular Coleto Creek in the west and Arenosa and Garcitas Creeks in the east. Vascular plant development in the river and larger creeks is limited because of high turbidity. In most sections of the river, it is relatively slow moving. Therefore, vegetation along the edges of the river, and similarly along the edges of the larger creeks, is similar to that along the edges of the ponds when the river and creek banks have a gradual slope. Where the river and creek banks drop abruptly into the river, the aquatic vegetation is limited to a thin strip of wetland species. In many of these abrupt areas, the canopies of the riparian trees overhang much of the river. Upslope from the river and creek banks, the vegetation transitions to riparian or mesquite woodland, a wetland, or a shrubland depending on conditions adjacent to the bank.

Many of the smaller creeks are ephemeral streams. Along these creeks, the banks generally support mixed woodlands or Macartney rose thickets, the widths of which may vary from 10-100 m. The streambeds are often bare of vegetation if water flows fairly frequently, but most of these streambeds are covered with forbs and grasses during dry periods. Giant ragweed (*Ambrosia trifida*), also known as bloodweed, is the most common of these species and often forms dense stands 2-3 m tall.

### 6.2.5 Agricultural

Approximately 80,000 acres (14%) in Victoria County were under cultivation in 2012 (USDA Census of Agriculture). This compares to about 120,000 acres that were under cultivation in 1967 (Miller 1982). The major crops are grain sorghum, corn, and cotton, with some soybeans and rice. Approximately another 50,000 acres are in improved pasture where the major improved pasture species are bermudagrass (*Cynodon dactylon*), King Ranch bluestem (*Bothriochloa ischaemum*), and kleingrass (*Panicum coloratum*). Improved pastures in Victoria County are subject to invasion by woody species, especially huisache and mesquite. Woody plant invasion is slower in pastures that are routinely hayed, but woody species still tend to invade over time, especially huisache which has the ability to spread low-growing branches horizontally beneath the cutting height for hay production. Because of invasion by woody plants, improved pastures must be routinely maintained or they will revert to savannas (open stand of small trees with grass understory) in 10-20 years and woodlands in 20-40 years.

## 6.3 Plant Communities

In EDYS, each cell is assigned an initial vegetation composition based on some combination of the plant species included in the application (Table 6.1). Because species composition field data are not available for each cell in the spatial footprint, initial vegetation assignments are made on the basis of plant communities. A first-approximation of species composition of each plant community, as well as their spatial distribution, is made using NRCS soil survey maps (Miller 1982). Each soil series is assigned an initial plant community based on NRCS ecological site descriptions (Table 5.1), other available literature (Appendix C), and professional experience. NRCS ecological site descriptions are largely based on late-successional conditions, which seldom occur on site. Instead, the sites are generally in a lower successional stage and often have some level of woody plant cover. Estimates of lower successional conditions and amounts of woody plant cover (estimated from aerial photographs) are used to adjust the literature data to arrive at initial estimates of species composition and biomass levels for each plant community.

An initial plant community may closely coincide spatially with its associated soil type. However, in some cases the plant communities associated with two or more soil types may be very similar and therefore were pooled. Conversely, visual observations from the aerial photographs may indicate that two or more areas in the same soil type have very different woody plant coverage, in which case they were separated into two or more plant communities.

Once all plant communities have been defined and mapped, all cells within a particular plant community are given the same initial species composition data. Although each cell in a vegetation polygon (initial plant community) has the same initial species composition, it does not necessarily remain the same during a simulation. Differences in topographic features, depths to groundwater, natural disturbances (e.g., fire), and management impacts (e.g., livestock grazing intensity, brush control) often result in some cells in the same initial vegetation type changing sufficiently that they form a separate and new vegetation type.

Eighteen initial native plant communities were identified for the Victoria County model (Table 6.3). These 18 communities were derived from the NRCS range sites and modified on the basis of information from the literature and from amounts of woody plant coverage (Appendix Table C.2). Woody plant coverage was estimated from NAIP aerial photographs and averaged 44.8% for rangelands in Victoria County overall and 41.0% averaged over all acreage in the county (Appendix Table C.28). Literature data used to modify the NRCS range site descriptions of the vegetation (Appendix C) were taken from Archer (1990), Archer et al. (1988), Bovey et al.

**Table 6.3 Initial native plant communities used in the Victoria County EDYS model, with their associated NRCS range sites and primary associated soil type.**

| Plant Community | Range Site | Primary Soil Type |
|---|---|---|
| **Clay Soils** | | |
| Huisache-little bluestem-buffalograss | Blackland | Lake Charles clay |
| Hackberry-live oak-Johnsongrass | Clayey Bottomland | Trinity clay |
| Huisache-gulf cordgrass-saltgrass | Salty Bottomland | Aransas clay |
| **Silty Clay Soils** | | |
| Live oak-hackberry-brownseed paspalum | Loamy Bottomland | Meguin silty clay |
| **Clay Loam Soils** | | |
| Huisache-little bluestem-ragweed | Clay loam | Weesatche sandy clay loam |
| Huisache-buffalograss-Texas wintergrass | Rolling Blackland | Denhawken-Elmendorf clay loam |
| Gulf cordgrass-saltgrass-sea oxeye | Salt Marsh | Placedo silty clay loam |
| **Loam Soils** | | |
| Huisache-buffalograss-hooded windmillgrass | Gray Sandy Loam | Sarnosa loam |
| **Sandy Loam Soils** | | |
| Macartney rose-little bluestem-knotroot bristlegrass | Claypan Prairie | Nada-Cieno sandy loam |
| Mesquite-little bluestem-brownseed paspalum | Loamy Prairie | Telferner fine sandy loam |
| Mesquite-little bluestem-balsamscale | Sandy Loam | Inez fine sandy loam |
| Mesquite-silver bluestem-purple threeawn | Tight Sandy Loam | Papalote fine sandy loam |
| **Sandy Soils** | | |
| Live oak-seacoast bluestem-balsamscale | Deep Sand | Kuy loamy sand |
| Live oak-little bluestem-thin paspalum | Loamy Sand | Leming loamy fine sand |
| Live oak-little bluestem-knotroot bristlegrass | Sandy Bottomland | Zalco sand |
| Mesquite-little bluestem-arrowfeather threeawn | Sandy Prairie | Fordtran loamy fine sand |
| **Shallow Soils** | | |
| Mesquite-little bluestem-silver bluestem | Gravelly | Tremona gravelly loamy sand |
| Blackbrush-silver bluestem-buffalograss | Shallow | Valco clay loam |

(1970, 1972), Box (1961), Box and White (1969), Buckley and Dodd (1969), Diamond and Smeins (1984), Dodd and Holtz (1972), Drawe (1994), Drawe and Box (1969), Drawe et al. (1978), Garza et al. (1994), Johnston (1963), McLendon (1991, 1994, 2015), McLendon and Dahl (1983), McLendon and DeYoung (1976), McLendon et al. (2012a. 2012b, 2012c, 2012d, 2013a, 2013b), Powell and Box (1967), Scifres et al. (1980), Smeins (1994a, 1994b), and Smeins and Diamond (1983).

**Table 6.4 Land-use types included in the Victoria County EDYS model.**

| Land-Use Type | Vegetation | Comment |
|---|---|---|
| Urban houses | live oak-mesquite-bermudagrass | 50% of area vegetated (lawns) |
| Buildings/industrial | hackberry-huisache-Johnsongrass | % woody plant cover from aerial photographs |
| Disturbed area | mesquite-hackberry-purple threeawn | % woody plant cover from aerial photographs |
| Caliche pit | mesquite-blackbrush-huisache | % woody plant cover from aerial photographs |
| Road | none | |
| Tilled (cultivated) | milo (grain sorghum) | |
| Orchard | pecan | |
| Open water | none | |

The urban houses type was considered to be 50% of the spatial area covered with buildings and pavement and 50% in yard. The grass component of the yards was simulated with bermudagrass as a surrogate species for the variety of lawn grasses and the woody plants were considered to be 76% live oak, 17% mesquite, and 7% pecan (*Carya illinioensis*), with the amount of canopy cover estimated from aerial photographs.

Woody plant cover in cells that were classified as buildings/industrial, disturbed areas, caliche pits, or oil/drill pads was considered to consist of combinations of hackberry (*Celtis laevigata)*, mesquite, huisache, and blackbrush. This vegetation was considered to be either on areas not cleared when the sites were disturbed or the plants were the result of re-invasion. Amount of canopy cover was estimated from aerial photographs.

Crops grown on individual cultivated fields vary throughout the county. No effort was made to distinguish different crops from the aerial photographs. Instead, all cultivated areas were assumed to be planted each year to milo (grain sorghum). All orchards were assumed to be pecan orchards.

There are several improved pasture species that are common in Victoria County. Most common are coastal bermudagrass, kleingrass, King Ranch bluestem, Kleberg bluestem (*Dichanthium annulatum*), and various types of forage sorghums (*Sorghum* spp.). Wheat is sometimes planted as a winter forage crop. Regardless of the species planted, other species tend to invade these improved pastures over time. Common invading woody species include huisache, mesquite, hackberry, and baccharis (*Baccharis texana*). Common invading herbaceous species include Johnsongrass, King Ranch bluestem, ragweed (*Ambrosia psilostachya*), and sunflower (*Helianthus annuus*).

The initial forage species planted in the improved pastures, the potential productivity of the pasture, and the most common invading species all vary by soil type, the pre-planting vegetation, and the surrounding vegetation (Appendix Table C.22). Determining what the current composition is for each of the improved pasture polygons would require a substantial effort. In addition, it is extremely difficult to determine the differences between improved pastures and some native grasslands in Victoria County. As a result, the improved pasture type was not used in the Victoria County EDYS model. Instead, areas predominately in grassland vegetation were considered to be the typical native grasslands associated with their respective soil type.

## 6.4 Spatial Heterogeneity of Vegetation

Simulation run times and memory requirements increase as the complexity of the model application increases. Model application complexity is determined by a number of factors. Of these, spatial heterogeneity has the greatest effect. Spatial heterogeneity includes several components. One component is number of cells, which is determined by cell size (40 m x 40 m in the Victoria County model) and the size of the overall spatial footprint of the model. A practical upper limit is about 1.5 million cells (Section 2.0).

Although EDYS can keep track of changes in condition in all 1.5 million cells at each time step, that is too many cells on which to simulate all ecological and hydrologic dynamics. Instead, EDYS simulates these dynamics for plot types and then applies the resulting value, at each time step, to all cells containing that particular plot type. For example, an area of mesquite-little bluestem grassland might contain 100 cells, each with the same vegetation and the same soil. Instead of making 100 sets of calculations for ecological and hydrologic dynamics for that area (polygon) at each time step, EDYS makes one set of calculations and then applies the results of those calculations to all 100 cells.

A plot type is a unique combination of soil, vegetation type (including land-use types), amount of woody plant cover, and precipitation zone. The Victoria County model contains 18 soil-vegetation types (Table 6.3) plus eight land-use types (Table 6.4). There are seven potential woody plant coverage categories (0-1%, 1-10%, 10-25%, 25-50%, 50-75%, 75-90%, 90-100%), but all coverage categories do not occur in all vegetation types. Accounting for woody plant coverages that do occur, there are 138 initial vegetation-coverage types (Appendix C.27).

Plot types often become subdivided during EDYS simulations. This happens when some disturbance or treatment factor (e.g., fire, sediment deposition, brush control, cross fencing, placement of water facilities) affects one part of the plot type but not another part. The affected part, including all cells in it, then becomes a different plot type (e.g., root-plowed huisache woodland). Depending on the length of the simulation run and the number of management options applied, this plot proliferation can increase the number of plot types during the simulation run by a factor of 4-5.

Because of plot type proliferation, the number of potential plot types in the Victoria County model may increase from 138 at the beginning of the simulation run to 700 or more at the end of the run. There are two approaches that can be taken to account for plot proliferation. One approach is to not allow it. This approach fixes the number of plot types at the original number.

The advantage in using this approach is that greater initial ecological spatial heterogeneity can be included. The disadvantage is that no spatial changes can occur during a simulation. The vegetation can change within a polygon but the polygon cannot be subdivided as a result of disturbance or management. The alternative approach is to reduce the number of initial plot types and then allow proliferation to occur during the simulation. The advantage of this approach is that the landscape becomes spatially dynamic as well as temporally dynamic. The disadvantage is that less ecological spatial heterogeneity can be included at the beginning of the simulation.

Which approach is selected depends on the relative importance of spatial dynamics versus increased spatial ecological complexity. For the Victoria County model, the second approach was selected. Spatial changes across the landscape, resulting from both natural and anthropogenic factors, were considered of high importance. In addition, much of the increased spatial complexity in ecological factors was considered to be of lesser importance. For example, differences in over half of the NRCS soil units (30 out of 49) were relatively minor variations based on slope and frequency of flooding (Section 5.1). Likewise, much of the fine-scale changes in plant species composition among vegetation types cannot be determined without substantial on-site vegetation mapping.

### 6.5 Plant Parameter Variables

EDYS is a mechanistic model. It simulates ecological dynamics by modeling how the various ecological components function. For plants, this is accomplished by using mathematical algorithms to model how plants grow and respond to various environmental stressors, such as drought, fire, and herbivory.

There are a large number of algorithms associated with plant dynamics in the EDYS model (Childress et al. 1999b; Coldren et al. 2011a). Each algorithm is applied to each plant species at each time step during a simulation to simulate the change in that plant or plant part from one time step to the next. Each algorithm contains one or more plant response variables (parameters). Differential responses among plant species are achieved in EDYS by assigning species-specific values to each of these plant parameters. For example, one of the algorithms is plant growth, more specifically, increase in plant biomass. This algorithm contains a number of parameters, one of which is "water to production". This parameter (water to production) is the amount of water (in kilograms) required to produce one gram of new plant biomass and it is species specific (i.e., the water-use efficiency varies by species). Two of the major perennial grasses in the Victoria County model are little bluestem and buffalograss (*Buchloe dactyloides*). The water-to-production value for little bluestem is 0.90 and the value for buffalograss is 0.74. Buffalograss is the more xeric of the two grasses and indeed has a higher water-use efficiency.

There are 346 plant parameter variables in EDYS and each one of these has a specifc value for each species in an application (66 species in the case of the Victoria County model). These variables are arranged into 37 matrices (Coldren et al. 2011a). Selected examples are presented in Appendix E, along with corresponding values for each of the species included in the Victoria County model.

General characteristics of each species are presented in Appendix Table E.1. Appendix Tables E.2-E.4 are the tissue allocation matrices. At each time step, EDYS calculates the amount of new biomass produced by each species. This amount is based on 1) amount of current photosynthetically active biomass, 2) potential growth rate, and 3) amount of required resources available to the species (function of amount of each resource available in the system and the competitive ability of the specific species to secure this resource). The amount of new biomass produced by each species is then allocated to the various plant parts based on the values in the allocation matrices.

Appendix Table E.2 provides the information that EDYS uses to allocate the beginning biomass values (Appendix Table C.2) to the various plant parts to begin a simulation. During a simulation, new biomass production is allocated during each time step to the various plant parts based on the values in Appendix Table E.3. For example, if 10 g of new biomass is produced by huisache, 0.8 g would be coarse roots, 2.0 g would be fine roots, 0.9 g would be added to the trunk, 2.2 g would be added to stems, and 4.1 g would be added to leaves. These ratios are used throughout the growing season, except in months when the species flowers or undergoes green-out. Green-out occurs following winter dormancy, drought dormancy, or following severe defoliation. For months when green-out occurs, the values from Appendix Table E.4 are used instead of the values from Appendix Table E.3.

Root architecture varies substantially among plant species and these variations are important in determining competitive responses among species for belowground resources (e.g., water and nutrients). Two components of root architecture of primary importance are distribution of roots by soil depth and maximum potential rooting depth. Appendix Table E.9 provides the values for these two parameters for each of the species included in the model. These values are used in EDYS to determine the initial spatial distribution of root biomass.

The amount of roots for a particular species at the beginning of a simulation is determined by multiplying the coarse and fine root allocation values (Appendix Table E.2) by the initial biomass value for that species in a given plot type (Appendix Table C.2). The values in Appendix Table E.9 are then used to allocate this root biomass (coarse and fine) by soil depth. This is calculated as the product of:

(total root biomass) (% in a portion of the rooting depth) (maximum potential rooting depth).

For example, 4% of the roots of huisache are assumed to be located in the first 1% of the rooting depth of huisache, which is 12.62 m (Appendix Table E.9). Therefore, 4% of the initial root biomass of huisache is located in the upper 126 mm of the soil. If the maximum depth of a soil in a particular plot type is less than the maximum potential rooting depth, the maximum soil depth is used instead.

The values in Appendix Table E.9 are used to calculate the initial distribution of roots in an EDYS simulation. At each time step during a simulation, new root biomass is added (e.g., Appendix Table E.3). This new root biomass is allocated to the current root biomass in those soil depths where active root uptake of water and nutrients is taking place. This results in potential changes in root distribution during a simulation caused by resource distribution.

Appendix Table E.11 provides values used to determine when specified physiological processes occur. These processes are 1) green-out (breaking of winter dormancy), 2) beginning of winter dormancy, 3) months in which flowering and seed production can occur, and 4) months in which seed germination can occur.

Appendix Table E.13 provides values used to determine water requirements of each species for maintenance and for production of new biomass. Maintenance water requirements (old and new growth) refers to the amount of water used each month to support existing biomass. Water to production is the amount of water required to produce 1 g of new biomass (i.e., water-use efficiency). Green-out requirement is the amount of water required to support the production of new biomass during green-out.

At each time step during the growing season for a particular species (Appendix Table E.11), EDYS calculates the amount of water that species would require if it produced at its maximum potential rate (Appendix Table E.14) plus the amount required for maintenance of existing tissue. EDYS then calculates how much soil moisture is available to that species at that time step, as determined by the distribution of moisture in the soil at that time and the competition for that water among all species with roots in each particular soil layer. If the amount of water available is equal to or greater than the amount required, the plant produces that much new biomass and that quantity of water is removed from the respective soil layers. If the amount of water available is less than the amount required, maintenance requirements are met first and any remaining water is used to produce new biomass, the amount of which is proportional to what can be produced on the remaining amount of water (water to production).

EDYS also determines nutrient requirements in a manner similar to water requirements. If nutrients are more limiting to plant growth than water requirements at that time step, the amount of new growth produced is determined by the amount of nutrients available rather the amount of water available, and the amount of water used is reduced proportionately.

Appendix Table E.14 provides values used to determine maximum potential growth rate, size of the plants, and the maximum rate of tissue loss from drought. Maximum potential growth rate is the maximum rate that new biomass can be produced, under optimum conditions for that species. Maximum potential growth rate is genetically determined for each species. Actual growth rate is most often less than this value because of resource limitations and tissue loss (e.g., herbivory, trampling). The values in Appendix Table E.14 are multiplied by the amount of photosynthetically-active tissue (Appendix Table E.16) present in that species at that time step. The product is the maximum amount of new tissue that species can produce in that particular month. The actual amount produced is generally less than this maximum amount, based on resource limitations (water, nutrients, light, temperature).

Maximum aboveground biomass is the maximum amount of standing crop biomass ($g/m^2$) that is possible for that species. This variable limits the accumulation of biomass to realistic levels for the species. Maximum old biomass drought loss is the maximum amount (proportion of existing biomass) that can be lost in one month from drought.

Appendix Table E.15 provides a seasonal growth function for each species. A value of 1.00 indicates that the species can potentially grow at its maximum rate (Appendix Table E.14) during that month. Values less than 1.00 result in proportional decreases in the maximum potential growth rate during those months. The values in the table are estimates based on responses to both temperature and photoperiod.

Maximum potential growth rates (Appendix Table E.14) are based on photosynthetically-active tissue. For most species, the tissue with the highest potential photosynthetic rate are the leaves. Cacti are an exception. Cacti leaves are their thorns. Cacti stems are the photosynthetically-active tissue in cacti. Roots and trunks of most species are structural tissues and do not contribute directly to photosynthesis, although there are exceptions (e.g., trunks of retama and paloverde trees). Stems of many species contribute somewhat to photosynthesis, but generally at a lower rate than leaves. Appendix Table E.16 provides values for the photosynthetic potential of each plant part for each species. The values are proportions of maximum rates for that species (leaves for most species).

Green-out in plants, whether as spring green-up or recovery from defoliation, requires an energy source. Carbohydrates stored in various tissues are used to produce the new biomass. Some storage is in areas near the meristematic regions (e.g., bud zones) whereas other storage is in more distant tissues (e.g., coarse roots, bases of trunks) and must be translocated to the points of new growth. In both cases, there is a loss of biomass (weight) in some tissue because of the loss of stored carbohydrates. Appendix Table E.17 provides values used to determine how much current biomass (stored carbohydrates) can be used to produce new tissue during green-out. A value of 1.00 indicates that the amount of tissue in that plant part can be doubled during a green-out month. A value of 0.10 indicates that 10% of the biomass in that plant part can be transformed into new biomass during one month of green-out. During a green-out month, that amount of biomass is removed from the supplying plant part and transferred to new biomass and allocated according to the ratios in Appendix Table E.4.

Appendix Table E.18 contains values for four physiological control variables. These variables are used in EDYS to assure that plant structure does not become unbalanced and that the conversion from seeds to new plant biomass occurs properly. Each species has a characteristic root:shoot ratio (Appendix Table E.9). This is the relative amount of roots and shoots for that species. However, these ratios change during the growth season as new aboveground biomass is added and over years as perennial tissues accumulate belowground. Growing season maximum root:shoot ratio is a control to keep too much root biomass accumulating over time. If this value is exceeded during a growing season, no new biomass is allocated to roots until the value drops below this maximum value. Growing season green-out shoot:root ratio has a similar function. Maximum 1-month seed germination limits the amount of the seed bank that can germinate in any one month. Maximum first-month seedling growth provides the value to convert germinated seed biomass to new plant biomass. The amount of germinated seed biomass is multiplied by this value and the product becomes new plant tissue for that species.

At the end of the growing season (Appendix Table E.11), plants enter winter dormancy (or summer dormancy for cool-season species) and lose some of their tissue. An obvious example is deciduous trees shedding their leaves in the fall. But other tissue losses also occur. Some stems die. There can be some loss of trunk biomass. Root death occurs. Appendix Table E.19 provides the values used to calculate these losses.

A major factor in competition among plant species in many areas is shading, i.e., competition for light. Tall plants have a shading effect on shorter plants. Appendix Table E.20 provides for this competitive response. The values listed are a reduction in maximum potential growth rate of the **shaded** species resulting from 100% canopy cover of the **shading** species. The values are estimates based on 1) relative heights of the species, 2) canopy foliage characteristics, and 3) shade-tolerance of the understory species. The values in Appendix Table E.20 do not represent the competitive effect of overstory species on understory species, only the direct effect of shading. Overstory species also affect the growth of understory species in other ways, e.g., competition for water and nutrients. Those competitive effects are simulated in EDYS using other parameters. The shading parameter only reflects competition for light.

In EDYS, values are averaged within a cell (Section 2.0), which are 40 m x 40 m in the Victoria County model. Within each cell, estimates are made of the amount of woody plant cover (e.g., 10-25%) based on aerial photographs (Section 6.4). A 25% cover of woody plants could result from various combinations of clusters (mottes) of trees and shrubs. In effect, the cell would consist of at least two vegetation types, one associated with the woody species clusters and distributed over 25% of the surface of the cell and the other associated with herbaceous vegetation in the interspaces and distributed over the remaining 75% of the cell. However, the EDYS routine is to average the two types across the cell because the cell is the smallest subdivision in an EDYS application. In effect, this reduces the size of the woody plants (25% of actual size in this example) and assumes that biomass is average (uniform) across the cell. If the shading factor is ignored, this averaging does not substantially alter the vegetation and hydrologic dynamics of the cell. But with shading, the effect is to reduce herbaceous understory vegetation across the entire cell instead of just under the woody plant clusters which cover 25% of the cell.

An update that will account for this spatial heterogeneity within a cell is under development. However, that update is not complete and cannot be included in the initial version of the Victoria County model. In the interim, the shading factor is utilized in the current version for the effect of woody species on other woody species (i.e., under the woody plant canopy) but not for the shading effect of woody species on herbaceous species. The shading factor is included to simulate the shading effect of herbaceous species on other herbaceous species (e.g., midgrasses shading shortgrasses). This dual-component approach allows dynamics of herbaceous species to be simulated in the portion not covered by woody species, while maintaining the major aspect of shading within the area covered by woody plants. This dual pattern is a major characteristic of the shrub and woodland mosaics of South Texas, which have little herbaceous vegetation under the woody canopies but relatively abundant grasses and forbs in the interspaces (Drawe et al. 1978; McLendon 1991). In addition, reduction in herbaceous species under woody plant canopies may not occur until cover of woody species increases above 30-50% (Scifres et al. 1982; Fuhlendorf et al. 1997).

## 7.0 ANIMALS

The animal component of EDYS consists of herbivory by different types of animals, both domestic and wildlife. Population dynamics, habitat requirements, and animal movements are not currently included in most applications, but can be included if required. Four types of herbivores are included in the Victoria County model (cattle, deer, rabbits, insects) and others can be added as needed.

Herbivory in EDYS is simulated using three matrices for each animal species included in the model. Examples are provided in Appendix E for cattle. The first matrix is the preference matrix (Appendix Table E.21). Each plant part (live and standing dead) are listed for each plant species in the model. For each part-species combination, a preference ranking is assigned for each animal species. A ranking of 1 indicates that the plant part of that plant species is among the highest preferred foods for that particular animal. A low ranking (30 in the case of cattle) indicates the material is largely avoided by that animal.

The second matrix is the competition matrix (Appendix Table E.22). The values in this matrix indicate the order that animal (cattle in the case of Appendix Table E.22) has access to that plant part (whether they actually prefer it or not). In general, insects are considered to have first access (value = 1). The third matrix is the utilization matrix (Appendix Table E.23). These values indicate how much (percent) of that plant material the animal species could utilize if it desired that plant part. For example, cattle cannot consume 100% of the basal portions of most grasses because of their mouth structure. On the other hand, horses and deer can harvest this material to ground level.

Actual consumption of plant material in EDYS is a three-step process. First the amount of daily consumption is calculated by multiplying the amount of the animal species (either biomass or number, depending on the species) by a daily consumption value. The second step is to determine what the animal species consumes that day. That is accomplished by use of the preference, competition, and utilization matrices. If 100% of the daily consumption is available to that species (competition and utilization matrices) in the most highly preferred plant parts and plant species (preference matrix), the animal consumes that amount of the most preferred plant part. If that much is not available, the animal consumes what is available of that plant part and then selects from the next most-preferred plant parts and plant species. This process continues until the daily consumption amount is achieved. The third step is to subtract the quantity consumed from the standing crop biomass of that plant species and plant part.

### 7.1 Insects

Insect herbivory is modeled in the Victoria County model as consumption by grasshoppers. An average density of 3 grasshoppers/$m^2$ is used, with an average consumption rate of 0.1 g/$m^2$/day.

### 7.2 Rabbits

Rabbits are considered to be eastern cottontails in the Victoria County model. An average density of about 0.3/ha (1 cottontail per 8 acres) was used. Rabbits are assumed to consume an amount of plant material equivalent to 5.4% of their body weight each day (Kanable 1977), or about 73 g per cottontail per day. This equals about 0.0022 g forage/$m^2$/day.

### 7.3 Deer

Daily food intake (dry-weight basis) by white-tailed deer in South Texas is equal to about 3.23% of their live body weight for high-quality feed (Wheaton 1981). Daily intake in the western portion of the Edwards Plateau has been estimated to be 2.2% of live body weight (Bryant et al. 1979). Mature white-tailed does average about 43 kg (95 lbs) on the Welder Wildlife Refuge (central Texas Coast) and mature bucks average about 63 kg (139 lbs)(Knowlton et al. 1979), and mature does in the western part of the Edwards Plateau weight about 45 kg (Bryant et al. 1979).

An average stocking rate of 0.164 deer/ha (1 deer/15 acres) was used in the Victoria County model. Using an average deer weight of 53 kg and a daily feed intake of 2.7% of body weight, this corresponds to an average daily feed intake of 1.43 kg/deer, or about 0.235 g/$m^2$ (2.1 lbs/ac).

In South Texas, deer consume a combination of shrubs, forbs, and grasses, with the specific combinations dependent on vegetation conditions of the site. In a mixed shrubland in Kleberg County, diets of free-ranging white-tailed deer (bite count method) consisted of 45% shrubs, 34% forbs, and 21% grasses (Graham 1982). In that study, a total of 141 plant species were consumed by deer over an 18-month period, with 22 plant species comprising a total of 80% of the diet. On the Welder Wildlife Refuge in San Patricio County, deer consumed 70-90% forbs, 10-20% grasses, and 3-10% shrubs (Chamrad et al. 1979; Kie et al. 1980). Based on preference ratings, deer on the Welder Wildlife Refuge selected mostly for forbs (69%), then for grasses (18%) and browse (13%)(Drawe and Box 1968). In Jim Hogg County, deer were found to consume 37% forbs, 33% browse, 18% cacti, and 2% grasses, with 10% of their rumen contents consisting on unidentifiable material (Everitt and Drawe 1974). White-tailed deer on the Sonora Experiment Station in the southwestern part of the Edwards Plateau were found to consume 61% shrubs, 31% forbs, and 8% grasses (Bryant et al. 1979).

### 7.4 Cattle

Cattle are primarily grazers (consumers of herbaceous species) instead of browsers (consumers of leaves and twigs of woody species)(Stoddart et al. 1975:257). In many systems, grasses make up 85-99% of the diets of cattle (Sanders 1975; Durham and Kothmann 1977; Frasure et al. 1979), although the proportion of grasses may be lower (75%) in South Texas (Drawe and Box 1968; Everitt et al. 1981). They consume some forbs, especially during seasons when grasses are dormant and the forbs are growing. Cattle also consume some shrubs, especially as a source of additional protein (Dalrymple et al. 1965; Herbel and Nelson 1966) or during the winter (Everitt et al. 1981). Cattle diets in South Texas often contain higher proporitons of shrubs (6-10%: Drawe and Box 1968; Frasure et al. 1979; Smith and McLendon 1981; McLendon et al. 1982) than cattle diets in many other areas because of the abundance and diversity of shrubs in South Texas.

The amount of forage intake by cattle depends on a number of factors, including type of forage, size of the animal, and reproductive state. Of particular importance are protein content, moisture content, and digestibility of the forage species. A general rule for herbivores is that their daily intake, expressed on a dry-weight basis, equals about 3% of their body weight. Using this rule, a 1000-lb cow would consume about 30 lbs of forage per day. Published results from five grazing studies indicate a range in daily forage intake of 25 lbs/AUD on a shallow-soil bluestem prairie in Kansas to 56 lbs/AUD on an upland bluestem prairie in Kansas, with an average of 34.0 lbs/AUD (Table 7.1). An average of 34 lbs/AUD was used as the estimated forage requirement in the Victoria County model.

**Table 7.1 Forage consumption rate (forage disappearance) by cattle in selected studies reported in the literature.**

| Vegetation | Location | Amount/AUD | | Reference |
|---|---|---|---|---|
| | | lbs | grams | |
| Bluestem prairie, upland | Kansas | 45.33 | 20,580 | Anderson et al. 1970 |
| Bluestem prairie, limestone breaks | Kansas | 24.59 | 11,164 | Anderson et al. 1970 |
| Bluestem prairie, upland | Kansas | 56.09 | 25,465 | Owensby & Anderson 1967 |
| Bluestem prairie, limestone breaks | Kansas | 30.28 | 13,747 | Owensby & Anderson 1967 |
| Bluestem prairie, medium stocking | Louisiana | 34 | 15,436 | Duvall & Linnartz 1967 |
| Bluestem prairie, heavy stocking | Louisiana | 26 | 11,804 | Duvall & Linnartz 1967 |
| Bluestem coastal sand prairie | Texas | 27.29 | 12,390 | Drawe & Box 1969 |
| Pasture, coastal Bermuda | Texas | 32.25 | 14,642 | McCawley 1978 |
| Pasture, kleingrass | Texas | 36.11 | 16,394 | McCawley 1978 |
| Pasture, Bell rhodesgrass | Texas | 28.09 | 12,753 | McCawley 1978 |
| Mean | | 34.00 | 15,438 | |

AUD = animal unit day = amount of forage (dry weight) consumed by a 1000-lb cow in one day.

Long-term moderate stocking rates under good management are often based on removal of 40-60% of annual forage production (Paulsen and Ares 1962; Duvall and Linnartz 1967; Owensby and Anderson 1967; Drawe and Box 1969; Anderson et al. 1970). Average annual forage production for each ecological type, under late-seral condition, for Victoria County is presented in the NRCS Soil Survey (Miller 1982). Average current forage production, accounting for the fact that most rangelands in South Texas are not in late-seral condition, was estimated at 70% of the values presented in the Soil Surveys (Appendix Table C.2). Proper management stocking rates were assumed to be based on 50% harvest of average available forage (Appendix Table C.22). These amounts were further reduced on the basis of amount of woody plant cover present (Appendix Tables C.24, C.27, and C.28).

The estimated amount of annual available forage was used to arrive at an estimated stocking rate for each EDYS plot type (Appendix Tables D.1 and D.2). Daily forage consumption rate (34 lbs/AUD, Table 6.1) was multiplied by 365 to arrive at an annual animal unit (AU) forage requirement. This value (12,410 lbs/AU) was divided by the estimated amount of annual available forage for each plot type (50% of forage production, Table 7.2). The medium stocking rates were used as the default values in the model. Averaged over all types, the mean stocking rates was 11.6 acres/AU for areas devoid of trees and shrubs (Table 7.2). This increased to 19.1 acres/AU when adjusted for woody plant cover.

**Table 7.2 Cattle stocking rates, initial forage estimates, and mean woody plant cover used in the Victoria County EDYS model. Values are averages over various woody plant cover values per type.**

| Range or Land Use Type | Annual Forage Production | | | | Stocking Rates | | Woody Cover |
|---|---|---|---|---|---|---|---|
| | No Woody Cover | | Mean Woody Cover | | No Woody | Mean Woody | Mean (%) |
| | ($g/m^2$) | (lbs/ac) | ($g/m^2$) | (lbs/ac) | Cover (ac/AU) | Cover (ac/AU) | |
| Blackland | 555 | 4940 | 422 | 3756 | 5.03 | 6.61 | 30.2 |
| Clayey Bottomland | 358 | 3186 | 193 | 1721 | 7.79 | 14.41 | 57.7 |
| Clay Loam | 308 | 2741 | 188 | 1672 | 9.06 | 14.84 | 48.9 |
| Claypan Prairie | 345 | 3071 | 91 | 811 | 8.08 | 30.57 | 92.0 |
| Deep Sand | 228 | 2029 | 87 | 775 | 12.23 | 31.99 | 77.2 |
| Gravelly | 224 | 1994 | 167 | 1488 | 12.45 | 16.68 | 31.7 |
| Gray Sandy Loam | 188 | 1673 | 94 | 837 | 14.84 | 29.69 | 62.8 |
| Loamy Bottomland | 447 | 3978 | 364 | 3238 | 6.24 | 7.67 | 23.2 |
| Loamy Prairie | 592 | 5269 | 184 | 1639 | 4.71 | 15.13 | 86.1 |
| Loamy Sand | 133 | 1184 | 92 | 815 | 20.96 | 30.42 | 39.1 |
| Rolling Blackland | 275 | 2448 | 193 | 1714 | 10.14 | 14.48 | 30.7 |
| Salt Marsh | 706 | 6283 | 518 | 4512 | 3.95 | 5.50 | 33.3 |
| Salty Bottomland | 350 | 3115 | 316 | 2816 | 7.97 | 8.77 | 12.0 |
| Sandy Bottomland | 194 | 1727 | 155 | 1376 | 14.38 | 18.01 | 25.4 |
| Sandy Loam | 384 | 3418 | 249 | 2215 | 7.26 | 11.20 | 44.2 |
| Sandy Prairie | 596 | 5304 | 318 | 2827 | 4.68 | 8.78 | 58.4 |
| Shallow | 141 | 1255 | 70 | 622 | 19.79 | 39.90 | 63.2 |
| Tight Sandy Loam | 412 | 3667 | 283 | 2523 | 6.77 | 9.84 | 39.0 |
| Disturbed Sites | 100 | 890 | 75 | 664 | 28.07 | 37.38 | 31.8 |
| Caliche pits | 100 | 890 | 93 | 823 | 28.07 | 30.12 | 9.4 |
| Simple Means | 332 | 2953 | 208 | 1842 | 11.62 | 19.10 | 44.8 |

The range or land-use types are divided in the model on the basis of amount of woody plant coverage, and stocking rates are adjusted proportionately. No woody cover = forage production and stocking rates without woody plants coverage (Appendix Table C.2). Mean woody plant cover = values averaged (weighted by number of cells) over all woody coverage classes for that type (Appendix Tables C.27 and C.28), i.e., reduced forage production because of woody plants.

The moderate stocking rates used in the model (Table 7.2) compare well with rates reported in published research studies in the coastal region. Light stocking rate (32% forage utilization) on a sandy loam site on the Welder Wildlife Refuge in San Patricio County was 15 acres/AU (Drawe and Box 1969), which compares with a moderate stocking rate of 11.2 acres/AU on sandy loam sites in the model (Table 7.2). A moderate stocking rate (46% utilization) on silt loam bluestem sites in central Louisiana was 8.1 acres/AU (Duvall and Linnartz 1967). The stocking rate used in the model on tight sandy loam sites was 9.8 acres/AU. A moderate to heavy stocking rate (61% utilization) on a seacoast bluestem clay prairie in Calhoun County, Texas, was 4.5 acres/AU (Durham and Kothmann 1977), which compares with the moderate stocking rate on blackland sites in the model of 6.6 ac/AU. The average stocking rate in these three published studies was 9.2 acres/AU, with a corresponding average utilization of 46%. The corresponding values in the model are 9.2 acres/AU with an average utilization of 50%.

### 7.5 Horses

The model has the capability of including horses in the grazing options. However, at the present they are not included because of lack of information on stocking rates and locations. Although there are a substantial number of horses in Victoria County, most of these do not consume most of their feed from range vegetation. Instead, substantial portions are provided as hay and concentrates. In addition, their numbers are not distributed evenly across the landscape. Most horses in Victoria County are maintained for pleasure and are confined to areas near urban areas or farmsteads. These uneven distribution and supplemental feed factors make it likely that uniform modeling assumptions will lead to more inaccurate estimates in the simulations than if horses are excluded at this point in the modeling effort. When included in the model, horses are considered to have the grazing equivalent of 1.25 AU (Stoddart et al. 1975), i.e., one horse consumes an equivalent amount of forage as 1.25 1000-lb cows.

### 7.6 Feral Hogs

Feral hogs are a major species of concern throughout Texas. They are physically destructive to many habitats, especially wetlands, they compete with native wildlife and domestic livestock for food and habitat space, and their numbers are increasing. Modeling the impacts of feral hogs at large landscape scales, such as the Victoria County model, is difficult and perhaps counter-productive for the same reasons that modeling the impacts by horses is difficult on a landscape basis. The density and distribution patterns of feral hogs are not documented on a county-wide scale. Therefore, any scenarios including these estimates would be subject to substantial speculation. A more productive approach is to model a specific scenario without feral hogs included and then compare those results to results from the same scenario except with specific spatial and density assumptions made relative to feral hog populations. This was the approach taken, for example, in EDYS modeling of feral hog impacts in the Upper Llano River Watershed Protection Plan (Broad et al. 2016). No such scenarios were included in the ten scenarios simulated for the Victoria County report.

## 8.0 CALIBRATION

Calibration in EDYS consists of adjustments of parameter values, if needed, to achieve target values for the output variables under consideration. Target values are derived from independent validation data, either experimental validation studies or existing field data, if these data are available. In the absence of independent validation data, values based on literature data and professional judgement are used.

### 8.1 Vegetation

Independent field validation data are not currently being collected in Victoria County. Because field validation data were not available, reasonable ecological estimates were used as target values for calibration comparisons.

#### 8.1.1 General Procedure

The approach used in the calibration process is to begin with one vegetation type, obtain reasonable results for that type, and then add a second type, the second type having a substantially different combination of species. Once acceptable calibration results are obtained for both types in combination, then a third type is added. This interative process is continued until a sufficient number of types are included that, in combination, include all the major species included in the model. In addition to adding types, variations in woody plant cover and differences in rainfall and grazing regimes are included in the calibration process.

EDYS contains a large number of variables (parameters; Section 6.5), the values of any combination of which can be adjusted during the calibration process. The following general procedure is used to determine which parameters are adjusted and to what extent.

Prior experience has shown vegetation responses in EDYS to be more sensitive to changes in some parameters than others. The calibration process starts with those parameters the model is known to be more sensitive to changes in. Examples include water-use efficiency, root architecture, potential growth rate, allocation of current production, and end of growing season dieback. For most of these variables, a range in values is available in our data base that has been compiled from various literature references and from our own field and greenhouse studies. For example, root architecture data for little bluestem is available from 13 profiles taken from nine published studies (Sperry 1935; Weaver and Zink 1946; Weaver 1947, 1950, 1954, 1958; Weaver and Darland 1949; Coupland and Bradshaw 1953; Jurena and Archer 2003). The calibration process begins using the mean of these 13 profiles. If necessary, the values of initial root biomass in each layer (Appendix Table E.9) can be changed to provide a better fit with expected little bluestem biomass values changes in the model simulations. However, whatever changes are made in the root architecture parameters for little bluestem must not exceed the range of values in the data base (i.e., the parameter values remain consistent with reported values in the literature). A second example is water-use efficiency. Silver bluestem is another major perennial grass species in the Victoria County model. McGinnies and Arnold (1939) reported an average water-use efficiency in production of new biomass for silver bluestem of 685 g water/g aboveground biomass. However, they reported a range over a two-year period of 337-1221, depending on season and amount of water available. The calibration converged on a value of 760 (Appendix Table E.13), which is very near the mean (765) of the values reported by McGinnies and Arnold (1939) for the period May-September in their study and well within the overall range of values they reported.

By comparing changes in biomass of various species within a vegetation type and changes in biomass of the same species among vegetation types between calibration runs, as parameter values are modified, it can be determined which variables are controlling the changes (sensitivity analysis). Values in these parameter sets can be changed and the results compared in the next simulation. Once the values of the major plant species have stabilized near their target values, the vegetation calibration process is considered to be complete. It should be emphasized that the completed calibration process results in single values for each of the parameters, i.e., the same value is used for that particular species for the respective parameter for all vegetation types in the model. The benefit of this approach is that simulated responses are consistent across vegetation types throughout the spatial landscape.

### 8.1.2 Examples

Six vegetation types were used to calibrate the model: blackland, claypan prairie, loamy prairie, sandy loam, loamy bottomland, and salty bottomland. These six types contained a combined total of 69% of the spatial landscape in the Victoria model. Ten-year simulations were conducted for each calibration run. For each calibration run, initial composition and associated standing crop biomass values were defined for all vegetation types in the model (Section 6.3) and the entire model was run of a 10-year simulation. This allowed for surface hydrology interactions among all the vegetation types over time. Standing crop biomass values for each species were downloaded for each of the calibration types at the end of October (approximate end of growing season for most species in the model) of each year of the simulation.

Calibration was first conducted without grazing by livestock for two reasons. First, studies of vegetation change over time (especially successional studies) generally utilize grazing exclosures. This is done in order to determine natural patterns of secondary succession. Likewise, the calibration process must first determine if changes in species composition in the simulations are proceding in a realistic ecological manner (e.g., trees and midgrasses increase during periods of higher rainfall and xeric shrubs and shortgrasses increase during periods of lower rainfall, forbs decrease as midgrasses increase and increase as midgrasses decrease). The second reason for initially excluding livestock grazing during calibration is that the actual level of livestock grazing is unknown for most, and perhaps all, the various spatial units (e.g., pastures, ranches) in a county-wide model. Therefore, if grazing was included the calibration the results would most likely reflect the effects of the grazing levels entered into the model rather than successional effects and responses to rainfall variations. Once the models were calibrated without livestock grazing, livestock grazing was included and the calibration simulations re-run to affirm that the response of grazing was reasonable.

Four calibration scenarios were conducted for each of the six vegetation types. The first scenario utilized a moderate precipitation regime (1963-72 daily rainfall data, annual mean = 36.76 inches; long-term mean = 36.91 inches) without livestock grazing. The second scenario used a 10-year dry precipitation regime (1947-56 daily rainfall data, annual mean = 26.83 inches) without livestock grazing. The third scenario used a 10-year wet precipitation regime (1998-2007 daily rainfall data, annual mean = 45.03 inches), without livestock grazing. The fourth scenario utilized the moderate precipitation regime (1963-72) but included cattle grazing at moderate stocking rates (Table 7.2).

#### 8.1.2.1 Blackland

Calibration began with Plot Type 35 (NRCS type = blackland; Appendix Table C.2), with 25-50% (38% mean) woody plant cover, using the moderate precipitation regime. The blackland type is one of the two most abundant types in the Victoria County model footprint, containing 18% of the area within the spatial footprint (Appendix Table C.28). It also contains 36 of the 66 (55%) plant species included in the model. Much of this type was probably once midgrass prairie with scattered wooded mottes, but now it often supports moderate to dense woodlands or shrublands unless recently cleared by brush control.

Type 35 is a blackland clay grassland with scattered clusters of woody species covering 25-50% of the surface. The shrub clusters are primarily huisache, Macartney rose, or mesquite stands, with some live oak. There is a moderate to sparse stand of herbaceous species under the shrub canopies and moderate to dense stands of grasses in the openings between the shrub stands. Total initial aboveground biomass was initially set at 3,003 $g/m^2$, of which 60% was tree biomass (mostly huisache and mesquite) and 22% was shrub biomass (mostly Macartney rose). The remaining 18% (535 $g/m^2$; 4762 lbs/ac) was grasses and forbs, which primarily occurred the interspaces between the shrub clusters. The herbaceous biomass consisted of a combination of midgrasses (32% of herbaceous biomass), shortgrasses (38% of herbaceous), and forbs (30% of herbaceous). The major midgrasses were little bluestem and smutgrass (*Sporobolus indicus*). The major shortgrasses were buffalograss and purple threeawn (*Aristida purpurea*), and ragweed and white-stem wild indigo (*Baptistia leucophaea*) were the primary forbs.

Under the moderate rainfall regime (1963-72; mean annual rainfall = 36.76 inches) and without livestock grazing, there was a moderate increase (8.8%) in total aboveground biomass at the end of ten years (Table 8.1). This increase suggests that the system has not reached overall equilibrium with precipitation. This increase in biomass was almost exclusively from an increase in woody species. Aboveground biomass of trees increased by 16.5% compared to initial conditions and shrubs increased by 21.7%. The increase in tree biomass was from an increase in huisache and the shrub increase was mostly from an increase in Macartney rose. Huisache increased by almost 40% (39.7%) over initial conditions. This compares to a 46% increase in huisache over 16 years on the Welder Wildlife Refuge (Box et al. 1979). Macartney rose increased 23% over initial conditions in the 10-year simulation, compared to an estimated 54% increase on Texas Coastal Prairies over 15 years (Scifres 1975, Meyer and Bovey 1990).

There was a 21% decrease in grass biomass over the ten years with this scenario, with two-thirds of this decrease coming from the shortgrasses (Table 8.1). This decrease in grasses was the result of the increase in woody species. Biomass of woody species increased 18% over initial conditions. This increase would result in about 45% average cover of woody species by the tenth year (38% initially x 1.18). A similar increase in huisache cover (from 38% to 45%) on the Welder Wildlife Refuge resulted in an estimated 17% decrease in grass production (Appendix Table C.24, data from Scrifes et al. 1982). A substantial part (29%) of the increase in woody species in the simulation was from Macartney rose and Macartney rose decreases understory vegetation more than does huisache. Therefore, the 21% decrease in grass biomass is reasonable.

Little bluestem, and to a lesser degree sideoats grama and Johnsongrass, were the only midgrasses that increased over the ten years (Table 8.1). Little bluestem is the site-dominant on these grasslands and was able to out-compete the other midgrasses in the remaining grassland openings. It increased 32% over the ten years and, if the woody species had not been present in such large amounts, would likely become the dominant species over time. Initially, little bluestem comprised slightly over 9% of the herbaceous biomass. By the tenth year, its relative biomass had doubled (18%).

**Table 8.1 Calibration results for 10-year simulations for the blackland, 25-50% woody cover, vegetation type (Plot Type 35), Victoria County EDYS model. Values are total aboveground biomass ($g/m^2$) in October (end of growing season) under three precipitation (PPT) regimes.**

| Lifeform/Species | Initial | Year 10, No Grazing | | | Year 10, Grazed |
|---|---|---|---|---|---|
| | | Mod PPT | Dry PPT | Wet PPT | Moderate PPT |
| Trees | 1809 | 2108 | 1954 | 2396 | 2010 |
| Shrubs | 659 | 802 | 751 | 845 | 664 |
| Midgrasses | 172 | 154 | 71 | 286 | 142 |
| Shortgrasses | 202 | 142 | 61 | 95 | 212 |
| Grass-likes | 14 | 17 | 5 | 52 | 85 |
| Forbs | 147 | 44 | 25 | 88 | 17 |
| Total | 3003 | 3267 | 2867 | 3762 | 3182 |
| Huisache | 945 | 1320 | 1176 | 1593 | 1177 |
| Hackberry | 107 | 89 | 91 | 91 | 69 |
| Mesquite | 649 | 597 | 586 | 578 | 667 |
| Live oak | 108 | 102 | 101 | 134 | 97 |
| Baccharis | 83 | 99 | 94 | 92 | 76 |
| Macartney rose | 542 | 668 | 629 | 712 | 555 |
| Greenbriar | 34 | 35 | 28 | 41 | 33 |
| Big bluestem | 3 | 2 | 1 | 3 | 2 |
| Bushy bluestem | 19 | 9 | 6 | 12 | 6 |
| Silver bluestem | 20 | 17 | 10 | 10 | 20 |
| Sideoats grama | 6 | 7 | 3 | 10 | 11 |
| Virginia wildrye | 8 | 1 | 1 | 1 | 1 |
| Switchgrass | 4 | 2 | 1 | 3 | 4 |
| Little bluestem | 50 | 66 | 26 | 100 | 95 |
| Plains bristlegrass | 4 | 2 | 1 | 9 | 0 |
| Indiangrass | 3 | 1 | 1 | 3 | 2 |
| Johnsongrass | 10 | 11 | 5 | 32 | 0 |
| Tall dropseed | 6 | 1 | 1 | 1 | 1 |
| Smutgrass | 39 | 35 | 15 | 102 | 0 |
| Purple threeawn | 30 | 16 | 6 | 18 | 64 |
| Buffalograss | 56 | 51 | 20 | 22 | 80 |
| Bermudagrass | 14 | 2 | 2 | 3 | 4 |
| Longtom | 16 | 12 | 4 | 5 | 0 |
| Brownseed paspalum | 25 | 36 | 17 | 36 | 0 |
| Thin paspalum | 28 | 6 | 5 | 5 | 5 |
| Knotroot bristlegrass | 21 | 18 | 6 | 5 | 58 |
| Texas wintergrass | 12 | 1 | 1 | 1 | 1 |
| Flatsedge | 14 | 17 | 5 | 52 | 85 |
| Ragweed | 56 | 11 | 5 | 19 | 46 |
| Wild indigo | 25 | 6 | 6 | 7 | 0 |
| Old-man's beard | 7 | 18 | 9 | 46 | 1 |
| Bundleflower | 3 | * | * | * | * |
| Frogfruit | 14 | 1 | 1 | 1 | 1 |
| Ruellia | 3 | 1 | 1 | 1 | 0 |
| Bush sunflower | 25 | 7 | 3 | 14 | 19 |
| Sunflower | 14 | 0 | 0 | 0 | 0 |

An asterick (*) indicates a trace amount ($< 0.5$ $g/m^2$).

Of the eight shortgrasses, only brownseed paspalum increased. Brownseed paspalum is a sub-dominant species in the bluestem prairies of the region and therefore might be expected to increase as succession progressed. There was a substantial decrease (70%) in forb biomass, resulting from the increase in woody species and the increase in little bluestem. The only exception was old-man's beard (*Clematis drummondii*), which more than doubled in biomass.

Old-man's beard is an aggressive twining species that can form dense stands under huisache canopies (Drawe et al. 1978). Only one grass-like species, flatsedge (*Cyperus odoratus*) was included in the simulations for this vegetation type. This species also increased over the 10-year simulation.

Changing the rainfall regime affected the vegetation dynamics (Table 8.1), which was expected. Under the dry regime (1947-56, mean = 26.83 inches), there was an increase in huisache but at a slower rate than under the moderate rainfall regime and there was a decrease in mesquite and live oak, in relation to both initial conditions and the moderate regime. Mesquite decreases in cover during drought periods in South Texas (Archer et al. 1988). Compared to their respective values under the moderate rainfall regime, all shrub species had lower values after 10 years, although both baccharis and Macartney rose increased over initial conditions.

Compared to their respective values under the moderate rainfall regime, all herbaceous species had equal or lower values under the dry regime. Herbaceous species were affected more by the dry regime than were woody species. This was, in part, because the woody species had deeper root systems and were therefore more able to extract deep moisture than were the herbaceous species, which were dependent on current precipitation. Overall, herbaceous biomass was 55% less under the dry regime than under the moderate regime, compared to only a 7% reduction for woody species. Average annual rainfall under the dry regime was 27% less than under the moderate regime.

Under the wet regime (1998-2007, mean = 45.03 inches), huisache, hackberry, and live oak increased more than they did under the moderate regime, but mesquite decreased slightly (Table 8.1). A decrease in mesquite cover following the return of relatively high rainfall levels following the drought of the 1950s was reported on clay and clay loam soils on the Welder Wildlife Refuge (Drawe et al. 1978). Huisache and live oak were particularly favored by the wet regime, with increases over the moderate regime of 21% and 31%, respectively. The greater proportional increase by live oak suggests that live oak is only marginally adapted to these soils under the moderate rainfall regime and may have been better adapted to past climatic conditions (Drawe et al. 1978). Macartney rose increased 7% compared to the moderate regime. The fact that Macartney rose increased less under the wet regime than the proportional increase in rainfall (22%), suggests that other factors are more limiting to its production at this higher moisture level.

Most herbaceous species increased in biomass under the wet regime compared to the moderate regime. There was a substantial increase in midgrasses (86%), which is typical of successional dynamics in bluestem grasslands (Weaver 1954; Jensen and Schumacher 1969). The blackland type is a climax midgrass prairie and the midgrasses were especially favored by the higher rainfall level. The midgrasses have higher amounts of roots in the upper 1-2 m of the soil profile than do woody species, therefore the midgrasses are better able to extract the soil moisture in the upper profile afforded by the higher rainfall. In particular, there were substantial increases (percentage-wise) in big bluestem, bushy bluestem (*Andropogon glomeratus*), sideoats grama, switchgrass, little bluestem, plains bristlegrass, indiangrass, Johnsongrass, and smutgrass. Shortgrasses declined under the wet regime in response to competition from the midgrasses. This is the typical successional pattern in prairie vegetation, mid- and tallgrasses are favored by wetter conditions and shortgrasses are favored, relative to midgrasses, by drier conditions. Flatsedge was also strongly favored by the wet regime, increasing three-fold over its production under the moderate regime. The larger forbs [ragweed, wild indigo, old-man's beard, bush sunflower (*Simsia calva*)] were favored by the wet regime, while the smaller forbs [bundleflower (*Desmanthus velutinus*), frogfruit (*Phyla nodiflora*), ruellia (*Ruellia nodiflora*)] were not.

Livestock grazing also had an impact on vegetation change in the calibration simulation (Table 8.1). A major difference between grazed and ungrazed was a decrease in midgrasses and an increase in shortgrasses under the grazing regime. Compared to ungrazed conditions at the end of 10 years, midgrass biomass was 8% lower and shortgrass biomass was 49% higher under grazed conditions than ungrazed. This is what would be expected to occur. Most of the midgrasses are more highly preferred forage species by cattle than most of the shortgrasses. Therefore, the midgrasses receive a higher proportion of the grazing pressure. Two midgrass species, plains bristlegrass and Johnsongrass, decreased the most. Both of these species are highly palatable to cattle. Silver bluestem, sideoats grama, and little bluestem increased under grazing. These species are less preferred by cattle than plains bristlegrass and Johnsongrass, and they are highly competitive. Smutgrass also decreased under the grazing scenario. Although smutgrass is not a preferred forage species by cattle, it does provide substantial forage during winter months (Durham and Kothmann 1977). On this particular site, this heavy grazing during winter months was sufficient to shift competitive advantage to other midgrasses.

Three shortgrass species [purple threeawn, buffalograss, and knotroot bristlegrass (*Setaria geniculata*)] increased substantially under the grazing scenario as compared to ungrazed (Table 8.1). These three species are adapted to grazing and increase on the Texas Coastal Prairie as livestock grazing increases. Longtom and brownseed paspalum decreased under the grazing scenario. Both of these species are relatively palatable species to cattle and therefore would be expected to decrease with grazing compared to ungrazed conditions.

Huisache biomass decreased by 10% under the grazing scenario, compared to the ungrazed scenario, whereas mesquite increased. Huisache is a palatable browse species whereas mesquite leaves are relatively unpalatable. The decrease in huisache was the result of greater browsing pressure, from cattle in early spring and during drier periods but especially from increased browsing from deer. As cattle removed more of the herbaceous material by their grazing, deer shifted more to browse.

Total aboveground biomass of herbaceous species was 456 $g/m^2$ in the tenth year with livestock grazing (Table 8.1). Total aboveground biomass in EDYS simulations includes the basal crown (trunk) biomass that is rarely sampled in clipping studies. Trunk biomass accounts for about 40% of total aboveground biomass of herbaceous species in EDYS simulations. Adjusting total aboveground herbaceous biomass to account only for clippable biomass results in a value of 274 $g/m^2$ of clippable biomass. This compares with 291 $g/m^2$ on a grazed bluestem-Macartney rose community in Calhoun County (Durham and Kothmann 1977) and 164 $g/m^2$ on a moderately grazed pasture on the Welder Wildlife Refuge 10 years after drought and heavy grazing (Box and White 1969).

### 8.1.2.2 Other Types

Five other vegetation plot types were used in the calibration process (Table 8.2). Combined with the area included in the blackland type, the six types include 69% of the area included in the spatial footprint of the model and 62 of the 66 (94%) plant species. Although all four calibration scenarios were run for each of the five additional types, only results of the moderate-rainfall no grazing scenarios are presented (Table 8.2) and discussed.

Trees increased over the ten years on two of the types (claypan prairie and salty bottomland), decreased on two (sandy loam and loamy bottomland), and remained about the same on one type (loamy prairie). Huisache increased more than 25% on the loamy prairie, claypan prairie, and salty bottomland types, but decreased 12-14% on the sandy loam and loamy bottomland sites. These two types had relatively low amounts of huisache present at the beginning of the simulation and it did not compete well against midgrasses on the sandy loam type and against Macartney rose and mustang grape on the loamy bottomland type. Live oak remained relatively stable on all the types, although it had a slight (5%) increase on the loamy bottomland type. Mesquite decreased on all of the types except salty bottomland, where it increased by 9%.

Shrubs increased on all five types. On the loamy prairie and claypan prairie types, this increase in shrubs was from Macartney rose, which increased by 35% and 41% on the two types, respectively. This is the approximate 10-year proportional increase (36%) for this species on the Texas Coastal Prairies based on regional data (Scifres 1975; Meyer and Bovey 1990). Both Macartney rose and mustang grape (*Vitis mustangensis*) were major contributors to the increase on the loamy bottomland type. Both of these species often form dense canopies on these bottomlands. Blackbrush and granjeno (*Celtis pallida*) increased on the drier sandy loam type in the absence of Macartney rose. The salt-tolerant sea oxeye (*Borrichia frutescens*) was the shrub that increased on the salty bottomland site.

Midgrasses increased over the 10-year simulation (Table 8.2), as would be expected under conditions of moderate rainfall and no grazing. The exception was the claypan prairie. All herbaceous types except the grass-likes decreased on this type, probably in response to the major increase in Macartney rose. Macartney rose increased by over 40% on this type and these dense thickets resulted in less open area available for the herbaceous species, which decreased 53% overall. The loamy prairie type also experienced a large increase (35%) in Macartney rose, and there was a corresponding decrease (24%) in herbaceous production on this type also. However, midgrasses increased slightly (12%) on this type, as a result of a 31% increase in little bluestem. Little bluestem is the dominant species on these sandy prairies (Drawe et al. 1978; Diamond and Smeins 1984; McLendon 1991) and successional dynamics over the ten years resulted in this midgrass dominating the interspaces between clusters of Macartney rose.

**Table 8.2 Initial (00) and tenth-year (10) values (aboveground biomass, g/m$^2$) for lifeforms and plant species in six of the vegetation types used in the vegetation calibration process (ungrazed, moderate rainfall scenario). Initial woody plant cover = 25-50% (mean = 38%).**

| Lifeform/Species | Plot 077 Loamy Prairie | | Plot 054 Claypan Prairie | | Plot 022 Sandy Loam | | Plot 047 Loamy Bottomland | | Plot 003 Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | 10 | 00 | 10 | 00 | 10 | 00 | 10 | 00 | 10 |
| Trees | 3090 | 3082 | 2010 | 2137 | 5052 | 4759 | 4607 | 4405 | 1602 | 3538 |
| Shrubs | 433 | 583 | 996 | 1337 | 139 | 200 | 427 | 601 | 93 | 116 |
| Midgrasses | 256 | 286 | 117 | 56 | 174 | 501 | 128 | 328 | 171 | 933 |
| Shortgrasses | 147 | 116 | 101 | 70 | 90 | 60 | 123 | 81 | 56 | 331 |
| Grass-likes | 8 | 1 | 21 | 36 | 0 | 0 | 58 | 30 | 17 | 39 |
| Forbs | 156 | 28 | 91 | 13 | 101 | 110 | 120 | 504 | 63 | 87 |
| Total | 4090 | 4096 | 3336 | 3649 | 5556 | 5630 | 5463 | 5949 | 2002 | 5044 |
| Huisache | 766 | 1015 | 766 | 980 | 128 | 111 | 255 | 225 | 1277 | 3185 |
| Pecan | 0 | 0 | 0 | 0 | 0 | 0 | 1059 | 959 | 0 | 0 |
| Hackberry | 268 | 223 | 0 | 0 | 268 | 222 | 804 | 673 | 0 | 0 |
| Mesquite | 974 | 798 | 162 | 130 | 1136 | 921 | 325 | 266 | 325 | 353 |
| Post oak | 0 | 0 | 0 | 0 | 273 | 225 | 0 | 0 | 0 | 0 |
| Live oak | 1082 | 1046 | 1082 | 1027 | 3247 | 3280 | 2164 | 2282 | 0 | 0 |
| Blackbrush | 0 | 0 | 0 | 0 | 45 | 60 | 0 | 0 | 0 | 0 |
| Baccharis | 0 | 0 | 104 | 101 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sea oxeye | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 102 |
| Granjeno | 0 | 0 | 153 | 117 | 94 | 140 | 0 | 0 | 0 | 0 |
| Macartney rose | 433 | 583 | 866 | 1222 | 0 | 0 | 217 | 322 | 0 | 0 |
| Rattlepod | 0 | 0 | 26 | 14 | 0 | 0 | 10 | 6 | 26 | 14 |
| Greenbriar | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 22 | 0 | 0 |
| Mustang grape | 0 | 0 | 0 | 0 | 0 | 0 | 179 | 251 | 0 | 0 |
| Big bluestem | 3 | 1 | 1 | * | 1 | 3 | 4 | 1 | 0 | 0 |
| Bushy bluestem | 25 | 12 | 17 | 9 | 0 | 0 | 21 | 72 | 0 | 0 |
| Arrowfeather | 0 | 0 | 0 | 0 | 25 | 21 | 0 | 0 | 0 | 0 |
| Silver bluestem | 0 | 0 | 0 | 0 | 25 | 7 | 13 | 3 | 0 | 0 |
| Sideoats grama | 0 | 0 | 0 | 0 | 3 | 15 | 14 | 10 | 0 | 0 |
| Virgnia wildrye | 4 | * | 0 | 0 | 3 | * | 12 | 1 | 0 | 0 |
| Balsamscale | 0 | 0 | 0 | 0 | 28 | 51 | 0 | 0 | 0 | 0 |
| Plains lovegrass | 4 | 1 | 0 | 0 | 6 | 3 | 0 | 0 | 0 | 0 |
| Switchgrass | 4 | 2 | 2 | 3 | 0 | 0 | 11 | 15 | 0 | 0 |
| Little bluestem | 167 | 219 | 66 | 33 | 70 | 369 | 22 | 34 | 1 | 3 |
| Plains bristle | 0 | 0 | 0 | 0 | 6 | 20 | 8 | 8 | 0 | 0 |
| Indiangrass | 4 | 2 | 3 | 1 | 1 | 11 | 6 | 9 | 0 | 0 |
| Johnsongrass | 17 | 28 | 0 | 0 | 0 | 0 | 17 | 175 | 0 | 0 |
| Gulf cordgrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 170 | 930 |
| Tall dropseed | 0 | 0 | 6 | 1 | 6 | 1 | 0 | 0 | 0 | 0 |
| Smutgrass | 28 | 21 | 22 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Purple threeawn | 11 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Buffalograss | 0 | 0 | 0 | 0 | 17 | 2 | 25 | 3 | 4 | 4 |
| Sandbur | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 |
| Hooded windmill | 0 | 0 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bermudagrass | 8 | 1 | 17 | 3 | 22 | 4 | 14 | 2 | 14 | 5 |
| Saltgrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 322 |
| Longtom | 25 | 7 | 28 | 7 | 0 | 0 | 17 | 4 | 0 | 0 |
| Brownseed paspalum | 49 | 80 | 7 | 8 | 21 | 45 | 28 | 65 | 0 | 0 |
| Thin paspalum | 22 | 4 | 14 | 2 | 13 | 2 | 0 | 0 | 0 | 0 |
| Knotroot bristle | 25 | 21 | 28 | 49 | 5 | 2 | 29 | 6 | 0 | 0 |
| Texas wintergrass | 7 | 1 | 0 | 0 | 8 | 1 | 10 | 1 | 0 | 0 |
| Littletooth sedge | 8 | 1 | 11 | 21 | 0 | 0 | 35 | 10 | 0 | 0 |
| Flatsedge | 0 | 0 | 10 | 15 | 0 | 0 | 23 | 20 | 0 | 0 |
| Olney bulrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 39 |

**Table 8.2 (Cont.)**

| Lifeform/Species | Loamy Prairie | | Claypan Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | 10 | 00 | 10 | 00 | 10 | 00 | 10 | 00 | 10 |
| Ragweed | 70 | 13 | 28 | 5 | 39 | 68 | 28 | 395 | 0 | 0 |
| Spiny aster | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 8 | 17 | 16 |
| Wild indigo | 22 | 6 | 33 | 8 | 0 | 0 | 4 | 1 | 0 | 0 |
| Old-man's beard | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 98 | 0 | 0 |
| Bundleflower | 8 | 1 | 6 | * | 1 | * | 1 | * | 0 | 0 |
| Frogfruit | 0 | 0 | 4 | * | 0 | 0 | 3 | * | 0 | 0 |
| Snoutbean | 4 | 1 | 0 | 0 | 4 | * | 3 | * | 0 | 0 |
| Bush sunflower | 22 | 7 | 0 | 0 | 14 | 41 | 0 | 0 | 0 | 0 |
| Giant ragweed | 0 | 0 | 0 | 0 | 0 | 0 | 34 | * | 0 | 0 |
| Partridge pea | 2 | * | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 |
| Texas doveweed | 0 | 0 | 10 | 0 | 8 | 0 | 0 | 0 | 0 | 0 |
| Broomweed | 0 | 0 | 6 | 0 | 28 | 0 | 0 | 0 | 0 | 0 |
| Sunflower | 22 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 |
| Sumpweed | 6 | * | 4 | * | 3 | * | 3 | 2 | 25 | * |
| Glasswort | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 71 |

An asterick (*) indicates a trace amount (< 0.5 g/m$^2$).

Little bluestem increased greatly on the sandy loam type, where there was no competition from Macartney rose. Little bluestem increased from an intial aboveground biomass of 70 g/m$^2$ and comprising 19% of the herbaceous biomass, to 369 g/m$^2$ and 55% of the herbaceous biomass ten years later (Table 8.2). These values are consistent with those from research studies in the area. An ungrazed bluestem grassland at Aransas National Wildlife Refuge (ANWR) had an average aboveground biomass of 380 g/m$^2$, of which 72% was seacoast bluestem (McLendon 2014). Converting the EDYS value of 369 g/m$^2$ of total aboveground biomass to clippable biomass results in 221 g/m$^2$, which is similar to the ANWR seacoast bluestem value of 274 g/m$^2$ (380 g/m$^2$ x 0.72). Diamond and Smiens (1984) reported that the average composition of little bluestem on late-successional grasslands in the Upper Texas Coast was 41%. The mean composition from these two studies is 57%, compared to 55% from the EDYS simulations.

There were also major increases in midgrasses on the loamy bottomland and salty bottomland types. Johnsongrass was the primary species that increased on the loamy bottomland type, increasing ten-fold over the decade of the simulation. Johnsongrass is an aggressive midgrass that is particularly well adapted to mesic conditions. Although it rapidly decreases under heavy livestock grazing, it can rapidly dominate moist sites in the absence of livestock grazing. Gulf cordgrass was the species that contributed the most to the increase in grasses on the salty bottomland site and saltgrass (*Distichlis spicata*) was the second major contributor. Total aboveground biomass of gulf cordgrass at the end of the simulation was 930 g/m$^2$ (Table 8.2), or 558 g/m$^2$ of clippable biomass (60% of total). An ungrazed gulf cordgrass community on the Welder Wildlife Refuge averaged 543 g/m$^2$ clippable biomass (Garza et al. 1994). Eighteen *Spartina*-dominated plots on ANWR in which saltgrass was the sub-dominant species had an average saltgrass clippable biomass of 156 g/m$^2$ (McLendon 2014). This compares to an average clippable biomass value of 193 g/m$^2$ in the EDYS simulations.

Biomass of shortgrasses decreased on four of the five types, the exception being the salty bottomland type where the major shortgrass was saltgrass. The decrease in shortgrasses was the result of increased competition from woody species and from midgrasses. This is the expected successional response. Although shortgrasses as a group decreased, this was not true of all shortgrasses species. Brownseed paspalum increased on all four types where it was a component. Brownseed paspalum is a mid-seral species on many of these grassland communities and therefore increased as succession moved toward later stages. Knotroot bristlegrass decreased on most types but increased on the claypan prairie. This was the type where midgrasses decreased and knotroot bristlegrass was able to take advantage of the decreased competition from other herbaceous species.

Most forb species decreased as the midgrasses and woody species increased. There were however some exceptions. Ragweed increased on the sandy loam and loamy bottomland types, bush sunflower increased on the sandy loam type, and old-man's beard increased on the loamy bottomland type. All three of these species are larger plants and were able to successfully compete with the associated midgrasses. Ragweed and old-man's beard were especially successful on the loamy bottomland type, together comprising 52% of the herbaceous vegetation at the end of the simulation. These high levels of forbs are not uncommon on these bottomland types, with dense stands of ragweed, giant ragweed (bloodweed, *Ambrosia trifida*), and old-man's beard occurring in the openings and under the tree canopies. Validation study plots on the San Antonio River bottomland in Goliad County supported dense stands of giant ragweed (484 $g/m^2$, 86% relative biomass; McLendon 2015) and old-man's beard often forms dense stands on low areas throughout the region (Drawe et al. 1978; McLendon 1991).

The calibration results for vegetation dynamics provided species composition and production values that were in agreement with values and patterns reported in the literature. There was a general increase in woody species, especially huisache and Macartney rose, over time. Midgrasses increased and shortgrasses decreased over time, with the rate of increase higher under the wet regime than under the moderate precipitation regime. The reverse, midgrasses decreased and shortgrasses increased, under the dry and the grazed regimes. Within lifeforms (trees, shrubs, midgrasses, shortgrasses, and forbs), changes in species composition reflected characteristic successional patterns for the region. Based on these results, the calibration of the model was considered to be successful for vegetation dynamics.

### 8.2 Ecohydrology

Three ecohydrological components were assessed in the model calibration: 1) evapotranspiration, 2) surface runoff and sedimentation, and 3) groundwater use by vegetation. These components were also combined to develop several basic water balances. Direct field data were not available for use in these calibrations. Instead, literature values and professional judgment were used.

#### 8.2.1 Evapotranspiration

In EDYS, evapotranspiration (ET) is separated into its two components: evaporation (E) and transpiration (T). Evaporation is the conversion of liquid water to water vapor, with the subsequent movement of the water vapor into the atmosphere. Transpiration is the process of water loss from plants by evaporation through their stomates. In EDYS, transpiration is accounted for as a function of water use by individual plant species. Evaporation is subdivided into interception and evaporation, where interception is the amount of water intercepted by the vegetation canopy and then evaporated and evaporation is the amount of water evaporated from the soil (including bare ground, litter, and rocks and other bare surfaces) and open water surfaces.

The amount of ET varies widely among plant communities, regions, seasons, and years. Three primary variables determining the amount of ET are 1) temperature, 2) available moisture, and 3) vegetation. Warmer regions, or warmer seasons, have higher ET rates than cooler regions or seasons, other factors held constant. Under the same temperature regime, an increase in available moisture results in an increase in ET. Conversely, as conditions become drier, less water is available for evaporation and transpiration and therefore ET decreases. However, drier regions are often warmer than mesic regions and this increase in temperature also has an effect on ET rates. Potential evaporation rates are often estimated for a locale from measurement of evaporation from a free-water surface. Evaporation rates from exposed surfaces (e.g., leaf surfaces, rocks, surface of the litter) may approximate this rate. Evaporation from a soil surface is generally less than the maximum potential rate because the water is being translocated to the surface from which evaporation actually occurs and this translocation process slows the rate of evaporation. If the soil surface is shaded, for example by vegetation cover, the lower temperature also reduces the evaporation rate.

Plants move water from various soil depths, into their roots, through the plant, and into stomatal cavities where the evaporation actually occurs. This movement of water is in response to a water potential gradient between the various soil layers and the atmosphere at the leaf surface. The largest gradient occurs when the atmosphere is very dry and the soil is very wet. Very little transpiration occurs when the atmosphere is moist (high relative humidity) or when the soil is very dry. In the first case, the water potential gradient is too weak to result in much water movement. In the second case, there is too little water to move.

Therefore the transpiration **rate** is largely dependent on the water potential gradient and the amount of water available to the roots. However, the **amount** of transpiration is largely dependent on the amount, and type, of vegetation present and the amount of water available to the plants. As the amount of transpiring surface (primarily leaf surface area) increases, the amount of water transpired increases, provided there is sufficient moisture available in the rooting zone of the particular vegetation. For example, ET in mesquite-shrublands at a site in South Texas was about 37% higher than on bare soil in wet years, but only about 30% higher on adjacent shortgrass sites than on bare soil (Table 8.3). In dry years, ET from bare soil decreased by almost 68% compared to wet years and ET decreased by about 64% on vegetated sites.

**Table 8.3 Evapotranspiration (ET; mm) and rainfall (PPT; mm) in dry and wet years on the La Copita Experiment Station in South Texas (data from Weltz and Blackburn 1995).**

| Vegetation | Dry Year | | | Wet Year | | |
|---|---|---|---|---|---|---|
| | PPT | ET | ET/PPT | PPT | ET | ET/PPT |
| Mesquite-granjeno shrubland | 310 | 330 | 1.06 | 887 | 881 | 0.99 |
| Red grama-threeawn grassland | 310 | 298 | 0.96 | 887 | 833 | 0.94 |
| Bare soil | 310 | 208 | 0.67 | 887 | 643 | 0.72 |

The ET from the bare soil (Table 8.3) was all from evaporation (E) and evaporation from a soil surface is limited to the upper soil layers. Therefore, any moisture that percolates past these surface layers is largely protected from loss by evaporation. Red grama (*Bouteloua trifida*) and threeawn are relatively shallow-rooted grasses, but they can extract soil moisture from deeper soil depths than can be extracted by evaporation alone. Consequently, the ET values on the grassland were higher than ET values on the bare soil. Mesquite and granjeno are woody species that have deeper root systems than red grama and threeawn. Therefore, there is additional soil moisture available to them than is available to the shortgrasses. Consequently, the ET values on the shrubland was higher than on the grassland.

Under conditions of limited available moisture, the effect of plant species on ET rates is primarily a function of different rooting depths among species. In dry years, the mesquite-granjeno community ET exceeded the amount of rainfall received that year (Table 8.3), indicating the use of deeper soil moisture that had been stored during previous wetter years. Conversely, the ET of the shallower-rooted grasses was less than the annual rainfall. In the wet year, the amount of rainfall received exceeded the annual ET capacity of both the shrubland and the grasses, resulting in a net storage of soil moisture in the deeper soil layers. Deep soil moisture provided 25-50% of the transpiration water used by the shrub big sagebrush (*Artemisia tridentata*) in a grass-shrub stand in Utah (Caldwell and Richards 1989).

Differences in root architecture can also have a substantial effect on ET when deeper soil layers contain higher soil moisture. On an arid site in eastern California, a saltgrass community containing some rabbitbrush (*Chrysothamnus nauseosus*) had an annual ET of 47.2 cm (18.6 inches) and a nearby rabbitbrush-sacaton community had an annual ET of 60.5 cm (23.8 inches)(Duell 1990). Both communities had similar depth to groundwater (3.3 and 3.2 m, respectively). The reason for the higher ET in the rabbitbrush-sacaton community was because of the abundance of the deeper-rooted rabbitbrush shrubs and alkali sacaton (*Sporobolus airoides*), which is a deep-rooted perennial grass. In a similar study in southern Arizona, a big sacaton (*Sporobolus wrightii*) community had an ET of less than half that of an adjacent deeper-rooted mesquite community at similar depths to groundwater (Table 8.4).

**Table 8.4 Evaporation (ET) and depth to groundwater for two communities on the San Pedro River floodplain in southern Arizona (data from Scott et al. 2000, 2006).**

| | Big sacaton grassland | | Mesquite woodland | |
|---|---|---|---|---|
| Depth to groundwater (m) | 2.5 | 3.0 | 2.0 | 10.0 |
| Evapotranspiration (cm) | 40.6 | 27.2 | 84.8 | 63.8 |
| Evapotranspiration (inches) | 16.0 | 10.7 | 33.4 | 25.1 |

In arid regions, evaporation often comprises the greater portion of ET because vegetative cover is low. In more mesic regions, transpiration comprises the greater portion of ET because of higher vegetative cover, less bare ground, and cooler soil surfaces because of shading. In the Owens Valley of eastern California, a part of the Mojave Desert with a high water table, ET for three species of grasses with an average canopy cover of 37% had an average E:T ratio of 55:45, with a range of 40-69% evaporation (Evans et al. 2013; Mata-Gonzalez et al. 2014). A desert site in North Africa had an average E:T ratio of 57:43, with a range of 38-78% evaporation (Floret et al. 1982).

### 8.2.1.1 Blackland Type

The blackland type (Plot Type 35) is a blackland clay grassland with scattered clusters of woody species covering 25-50% of the surface. The woody species consist mostly of huisache, Macartney rose, and mesquite, with some live oak (Table 8.1). There is a moderate to sparse stand of herbaceous species under the shrub canopies and moderate to dense stands of grasses in the openings. The major grasses are little bluestem, smutgrass, buffalograss, and purple threeawn. The major forbs are ragweed and white-stem wild indigo.

Annual rainfall used in the 10-year calibration under the moderate rainfall scenario varied between 22.05 inches and 49.32 inches, and averaged 36.74 inches. Simulated annual ET averaged 35.31 inches, or 96% of annual precipitation. This equates to an ET rate of 3.7 mm/day for a 245-day growing season (March-October) or an annual (365-day) ET rate of 2.5 mm/day. These are reasonable rates based on literature values. An average daily rate for a mesquite-granjeno community in South Texas ws 2.6 mm (Weltz and Blackburn 1995) and 2.5 mm for a mesquite riparian community in southern Arizona (Scott et al. 2000, 2006). Likewise, the simulated ET equivalent of 96% of annual precipitation is similar to the 97% value reported for mesquite-grasslands in the Rolling Plains of Texas (Carlson et al. 1990), 95% for oak-grasslands in the Edwards Plateau (Thurow et al. 1988), and 94% on bluestem prairie in Kansas (Bremer et al. 2001).

The ratio of annual ET to annual rainfall fluctuates among years, in part because the supply of soil water is not entirely dependent on the amount of rainfall received in the particular year. Some soil water may be carried over from a previous year and late-season rainfall may not be fully utilized by plants in the year the rainfall was received (Table 8.5). ET exceeded annual rainfall in one-third of the years in the Rolling Plains study (Table 8.5). By comparison, ET exceeded annual rainfall in 30% of the years of the calibration simulations (Table 8.6).

**Table 8.5 Annual rainfall and evapotranspiration (ET) at sites in the Rolling Plains (Carlson et al. 1990) and in South Texas (Weltz and Blackburn 1995) in wet and dry years.**

| | Rolling Plains | | | | | | South Texas | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grassland | | | Mesquite-Grassland | | | Grassland | | Mesquite-Granjeno | |
| Rainfall (mm) | 769 | 677 | 629 | 769 | 677 | 629 | 310 | 887 | 310 | 887 |
| ET (mm) | 644 | 804 | 555 | 658 | 756 | 511 | 298 | 833 | 330 | 881 |
| Balance (mm) | +125 | -127 | + 74 | - 79 | +118 | + 12 | + 12 | + 54 | - 20 | + 6 |
| ET/Rainfall | 0.86 | 1.19 | 0.88 | 0.86 | 1.12 | 0.81 | 0.96 | 0.94 | 1.06 | 0.99 |

**Table 8.6 Annual rainfall (inches) and evapotranspiration (ET) variables (inches) for the 10-year baseline (moderate rainfall regime, no livestock grazing) calibration simulation for the blackland type, Victoria County EDYS model.**

| PPT Year | Rainfall | Interception | Evaporation | Total Evaporation | Transpiration | ET | Balance (Rainfall – ET) | ET/Rainfall |
|---|---|---|---|---|---|---|---|---|
| 1963 | 22.05 | 2.06 | 0.40 | 2.46 | 22.23 | 24.69 | - 2.64 | 1.120 |
| 1964 | 33.30 | 2.55 | 0.31 | 2.86 | 28.44 | 31.30 | 2.00 | 0.940 |
| 1965 | 30.85 | 2.09 | 0.31 | 2.40 | 25.93 | 28.33 | 2.52 | 0.918 |
| 1966 | 35.44 | 2.75 | 0.29 | 3.04 | 33.75 | 36.79 | - 1.35 | 1.038 |
| 1967 | 33.88 | 1.50 | 0.29 | 1.79 | 25.71 | 27.50 | 6.38 | 0.812 |
| 1968 | 49.29 | 3.65 | 0.37 | 4.02 | 42.56 | 46.58 | 2.71 | 0.945 |
| 1969 | 44.61 | 2.86 | 0.31 | 3.17 | 38.37 | 41.54 | 3.07 | 0.931 |
| 1970 | 39.76 | 3.04 | 0.31 | 3.35 | 38.06 | 41.41 | - 1.65 | 1.041 |
| 1971 | 36.04 | 2.08 | 0.33 | 2.41 | 32.19 | 34.60 | 1.44 | 0.960 |
| 1972 | 42.14 | 3.30 | 0.30 | 3.60 | 36.77 | 40.37 | 1.77 | 0.958 |
| MEAN | 36.74 | 2.59 | 0.32 | 2.91 | 32.40 | 35.31 | 1.43 | 0.961[1] |

[1] Calculated on the basis of (Mean ET)/(Mean Rainfall) instead of 10-year mean of ET/Rainfall.

The vegetation on the blackland type intercepted an annual average of 2.59 inches of rainfall in the calibration simulations (Table 8.6), or an average of 7% of annual rainfall. This is comparable with values reported in the literature for various vegetation types: 4% for shadscale shrubland in Utah (West and Gifford 1976), 8% for California grasslands (Corbett and Crouse 1968), 8% for huisache woodlands in Nuevo Leon (Carlyle-Moses 2004), and 11% for curly mesquite (*Hilaria belangeri*) and 18% for sideoats grama in the Edwards Plateau (Thurow et al. 1987). Transpiration accounted for 92% of total ET in the simulations, compared to 8% for total evaporation (Table 8.6).

#### 8.2.1.2 Other Vegetation Types

Average annual ET varied between 33.2 and 89.3 inches per year on the six types evaluated in the calibration (Table 8.7). The highest average annual ET was on the bottomland types where there was an abundance of mature trees and groundwater was near the surface. Average annual groundwater use by vegetation on the loamy bottomland type was 33.24 inches, or 53% of total annual ET for this type. Substantial use of shallow groundwater by trees has been reported in the literature. Ashe juniper (*Juniperus ashei*) has been reported to utilize up to 25% of its transpirational water from groundwater in some areas of the Edwards Plateau (Jackson et al. 2000), mature sugar maple (*Acer saccharum*) trees utilized groundwater almost exclusively when groundwater was at 3 m (Dawson 1996), and ET in mesquite riparian woodlands in southern Arizona was 33% higher when depth to groundwater was 2 m rather than 10 m (Scott et al. 2000, 2006). During drier periods of the year, velvet mesquite (*Prosopis velutina*) in southern Arizona primarily used groundwater (70% of transpiration; Snyder and Williams 2003). In shallow groundwater semiarid woodlands in Australia, trees utilized primarily groundwater 50-70% (depending on species) of the year in lower rainfall sites and 25-40% for the same species in higher rainfall areas (Cramer et al. 1999). In the dry season in the Northern Territory of Australia, riparian woodlands utilize 50% or more of the water they transpire from groundwater (Lamontagne et al. 2005) and during the drier portions of summers in wet forests of coastal British Columbia, Douglas fir (*Pseudotsuga menziesii*) trees extracted 15% of their transpired water from their deepest rooting depth (Nnyamah and Black 1977). Deep-rooted grasses can also utilize large amounts of groundwater when growing on sites with high water table and these amounts vary by the amount of rainfall received. On sites where depth to groundwater was less than 3 m (10 feet), alkali sacaton utilized 45% groundwater in dry years compared to 35% in wet years (McLendon et al. 2008).

**Table 8.7 Average annual rainfall (inches) and evapotranspiration (ET) variables (inches) for the 10-year baseline calibration simulations for six vegetation plot types, Victoria County EDYS model.**

| Type | Rainfall | Interception | Evaporation | Total Evaporation | Transpiration | ET | ET/Rainfall |
|---|---|---|---|---|---|---|---|
| Blackland | 36.74 | 2.59 | 0.32 | 2.91 | 32.40 | 35.31 | 0.961 |
| Claypan prairie | 36.74 | 2.76 | 0.32 | 3.08 | 30.12 | 33.20 | 0.906 |
| Loamy prairie | 36.74 | 2.25 | 0.34 | 2.59 | 33.22 | 35.81 | 0.975 |
| Sandy loam | 36.74 | 1.60 | 0.37 | 1.97 | 38.04 | 40.01 | 1.089 |
| Loamy bottomland | 36.74 | 3.13 | 0.41 | 3.54 | 59.65 | 63.19 | 1.720 |
| Salty bottomland | 36.74 | 5.14 | 0.37 | 5.51 | 83.77 | 89.28 | 2.430 |
| Mean | 36.74 | 2.91 | 0.36 | 3.27 | 46.20 | 49.47 | 1.344 |

Total ET on the loamy bottomland type averaged 63.2 inches per year (Table 8.7). Similar values have been reported for southwestern riparian woodlands, e.g., 50 inches (Scott et al. 2000), 58 inches (Devitt et al. 1998), 68 inches (Gay 1985), and 72 inches (Gatewood 1950). Total ET on the salty bottomland type, which was dominated by a dense stand of gulf cordgrass with abundant huisache (Table 8.2), was 89.3 inches, which is higher than commonly reported values for wet grasslands (38-53 inches; Larcher 1995, Scott et al. 2000, Mao 2002). The probable reason for the higher ET in the simulation was the presence of large amounts of huisache. A mesquite stand in South Texas had an annual ET of 34.7 inches (Weltz and Blackburn 1995) and a stand in southern Arizona with high groundwater had a rate of 33.4 inches (Unland et al. 1998). Combining the literature values for wet grasslands (38-53 inches) and mesquite (34 inches) results in a combined ET of 72-87 inches.

The four upland types (blackland, claypan prairie, loamy prairie, and sandy loam) were grasslands with substantial amounts of woody species (25-50% canopy cover). Annual ET on these sites averaged 33.2-40.0 inches (Table 8.7). These values are typical ET values for midgrass prairie and for mesquite and oak woodlands. Weltz and Blackburn (1995) reported an annual ET of 33.7 inches in a South Texas grassland and Carlson et al. (1990) reported an annual ET of 31.7 inches in a mixed prairie grassland in the Rolling Plains. Annual ET on a big bluestem-little bluestem prairie in Kansas was approximately 33 inches (= 28.4 inches measured during growing season + 4.7 inches estimated during dormant season)(Bremer et al. 2001). Annual ET on the four upland types averaged 98.3% of average annual rainfall (Table 8.7). This value compares favorably with published values for similar vegetation types: 94% for bluestem grassland (Bremer et al. 2001), 95% for oak-grassland (Thurow et al. 1988), 97% for mesquite grasslands in the Rolling Plains (Carlson et al. 1990), and 98% for mesquite shrublands in South Texas (Weltz and Blackburn 1995).

The average canopy interception rate for the six types was 8% of average annual rainfall (Table 8.7). This compares favorably with reported rates of 8% for huisache woodlands in northeast Mexico (Carlyle-Moses 2004) and chaparral communities in southern California (Hamilton and

Rowe 1949), 13% for *Acacia* woodlands in Australia (Pressland 1973), 8% for bluestem prairie in the Great Plains (Corbett and Crouse 1968), and 11-18% for grasslands in the Edwards Plateau (Thurow et al. 1987).

#### 8.2.1.3 Use of Groundwater by Vegetation

Vegetation has two primary supply sources for water used in transpiration, soil moisture and groundwater (including adjacent waterways). Over time, ET cannot exceed soil moisture unless the vegetation has access to groundwater. Depth to groundwater varies greatly over the Victoria County landscape (Table 8.8). Some vegetation types occur in areas where groundwater is deeper than the rooting depth of at least most of the plant species that occur in those types. At the other extreme are areas where groundwater is at or near the surface, e.g., bottomlands and wetlands, where groundwater is within the rooting zone of most, if not all, species present. In the former case, the vegetation is dependent on stored soil moisture and therefore, over time, dependent entirely on rainfall. In the later case, the vegetation is not entirely rainfall-dependent. And there are some areas where the groundwater is within the rooting zone of some species but not others.

**Table 8.8 Maximum, minimum and average depth to groundwater for the six vegetation types used in the calibration simulations for the Victoria County EDYS model.**

| Vegetation Type | Maximum | | Minimum | | Average | |
|---|---|---|---|---|---|---|
| | Meters | Feet | Meters | Feet | Meters | Feet |
| 35 Blackland, 38% woody | 12.17 | 39.92 | 0.87 | 2.85 | 1.73 | 5.67 |
| 54 Claypan prairie, 38% woody | 22.75 | 74.62 | 0.58 | 1.90 | 8.27 | 26.83 |
| 77 Loamy prairie, 38% woody | 23.46 | 76.95 | 0.48 | 1.57 | 10.28 | 33.72 |
| 22 Sandy loam, 38% woody | 26.16 | 85.80 | 0.26 | 0.85 | 6.84 | 22.41 |
| 47 Loamy bottomland, 38% woody | 13.65 | 44.77 | 0.26 | 0.85 | 2.67 | 8.76 |
| 03 Salty bottomland, 38% woody | 0.72 | 2.36 | 0.47 | 1.54 | 0.57 | 1.87 |

Each type has representative areas located in various parts of the County. Depth to groundwater varies among the different locations.

Except in wetlands and riparian floodplains, groundwater use by vegetation is largely confined to use by deep-rooted woody species. Most grasses have maximum rooting depths of 3-8 feet (1-2.5 m). Conversely, some woody species have root systems extending deeper than 25 feet (8 m). Live oak root systems have been reported as deep as 65 feet (Jackson et al. 1999) and mesquite roots deeper than 170 feet (Phillips 1963).

In riparian and other wetland environments, vegetation is largely dependent on a shallow water table (high groundwater). Many of the species occurring in these areas are either obligate phraetophytes or facultative phraetophytes able to utilize a high proportion of their transpirational water from groundwater or the capillary fringe immediately above the water table. The abundance of water at these sites results in high ET rates, substantially exceeding rates that can be sustained on precipitation alone. The difference between these ET rates and precipitation is approximately equal to the amount of groundwater utilized.

In general, groundwater use by vegetation varies along a typical toposequence, where usage is high in the lower riparian and wetland areas, intermediate in the upper floodplains, and low in the higher-elevation uplands. For example, annual groundwater use by vegetation in the calibration simulations was 2.0 inches on the claypan prairie type (upland), 6.9 inches on the sandy loam type (intermediate), and 33.2 inches on the loamy bottomland type.

Exceptions to this toposequence pattern are common. Some riparian trees growing adjacent to streams and rivers have been found to utilize little or no stream water (Dawson and Ehleringer 1991, Smith et al. 1991). In addition, proportions of water usage from groundwater can vary substantially among co-occurring trees on floodplains even when each species has roots in contact with groundwater (Meinzer et al. 1999; Cook and O'Grady 2006). Some upland species utilize relatively large amounts of groundwater. In the fractured limestone ecosystems of the Edwards Plateau, groundwater may supply as much as 24% of the water used by Ashe juniper (Jackson et al. 1999, 2000).

The amount of groundwater or other deep moisture sources used by vegetation can also vary in response to climatic and other environmental factors. Many woody species utilize deep moisture during dry periods, but shift to precipitation-derived sources in the upper soil profile when those become available (Sala et al. 1981; Comstock and Ehleringer 1992; Flanagan et al. 1992a, 1992b; Dawson 1993; Dawson and Pate 1996; Smith et al. 1997; Gebauer and Ehleringer 2000; Williams and Ehleringer 2000; Zeneich et al. 2002; Chimner and Cooper 2004). Consequently during wet years, vegetation may use proportionately less groundwater than during dry years. Age and condition of the plants may also affect the relative amounts of groundwater used. Tree saplings in riparian zones may utilize stream water whereas mature trees of the same species may use very little (Dawson and Ehleringer 1991). Defoliation was found to alter the source of water accessed by mesquite trees (Snyder and Williams 2003).

Groundwater use in the calibration simulations occurred on all six types, but the amounts were much less on the upland types (average of 2-6 inches per year) than on the lowland types (Table 8.9) where groundwater was near the surface. Averaged over the four upland types, groundwater useage was 3.7 inches per year under the moderate rainfall regime, or about 11% of annual transpiration (Table 8.7) or 10% of annual precipitation (Table 8.9). Most of the groundwater use on these four types was by the woody species. This is a reasonable amount of groundwater use by woody species on sites with these depths to groundwater. Average depth to groundwater (DTW), averaged over the four types, was 6.8 m, or 22.2 feet (Table 8.8). Two mesquite woodlands in Arizona where DTW was 10 m utilized over 30% groundwater (Snyder and Williams 2003), a woodland in Australia with a 7.5 m DTW utilized 7-11% groundwater (Cook and O'Grady 2006), and Ashe juniper in the Edwards Plateau may utilize as much as 25% of its transpirational water from groundwater sources (Jackson et al. 2000).

The vegetation of the loamy bottomland type utilized an average of 33.2 inches of groundwater per year (Table 8.9). This was equal to 56% of the total average transpiration on this type (Table 8.7). High rates of groundwater use (16-70%) are common for riparian vegetation (Dawson and Pate 1996; Zencich et al. 2002; Snyder and Williams 2003; Lamontagne et al. 2005; Cook and O'Grady 2006) and this high groundwater transpiration is how the riparian tree species maintain their high ET rates.

**Table 8.9 Annual rainfall (inches), annual evapotranspiration (ET, inches), and annual groundwater use (GW, inches) by six vegetation types used in the calibration simulations for the Victoria County EDYS model, under the moderate (baseline) precipitation scenario.**

| Year | Rainfall | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ET | GW | ET | GW | ET | GW | ET | GW | ET | GW | ET | GW |
| 1963 | 22.05 | 24.69 | 4.23 | 24.77 | 3.52 | 29.22 | 7.65 | 36.09 | 14.85 | 40.76 | 21.97 | 75.80 | 59.82 |
| 1964 | 33.30 | 31.30 | 3.21 | 31.61 | 2.32 | 34.33 | 5.40 | 40.61 | 9.08 | 62.76 | 34.01 | 119.34 | 90.18 |
| 1965 | 30.85 | 28.33 | 3.22 | 26.35 | 1.79 | 29.82 | 4.37 | 40.19 | 9.18 | 61.40 | 38.89 | 128.98 | 101.66 |
| 1966 | 35.44 | 36.79 | 3.03 | 37.60 | 3.24 | 39.60 | 3.03 | 44.19 | 10.26 | 74.09 | 39.19 | 122.76 | 87.53 |
| 1967 | 33.88 | 27.50 | 3.50 | 24.34 | 2.71 | 25.78 | 2.57 | 26.64 | 7.89 | 66.72 | 47.07 | 120.52 | 95.05 |
| 1968 | 49.29 | 46.58 | 2.86 | 44.45 | 1.00 | 45.89 | 1.26 | 44.43 | 0.00 | 78.25 | 33.48 | 103.02 | 61.33 |
| 1969 | 44.61 | 41.54 | 3.43 | 37.24 | 1.68 | 39.08 | 1.71 | 44.09 | 0.00 | 65.38 | 31.33 | 77.25 | 40.69 |
| 1970 | 39.76 | 41.41 | 3.35 | 36.96 | 1.59 | 40.67 | 1.47 | 45.74 | 3.02 | 58.01 | 24.28 | 64.46 | 27.14 |
| 1971 | 36.04 | 34.60 | 3.09 | 32.29 | 1.37 | 34.40 | 2.03 | 36.82 | 4.73 | 60.98 | 32.20 | 47.33 | 19.29 |
| 1972 | 42.14 | 40.37 | 2.97 | 36.30 | 1.00 | 39.32 | 1.92 | 41.41 | 3.55 | 63.56 | 29.99 | 33.23 | 1.26 |
| MEAN | 36.74 | 35.31 | 3.29 | 33.20 | 2.02 | 35.81 | 3.14 | 40.01 | 6.25 | 63.19 | 33.24 | 89.28 | 58.39 |

The groundwater-use amounts are included in the associated ET values.

Groundwater use was very high in the salty bottomland type, averaging 58 inches per year (Table 8.9). However, groundwater use declined rapidly in the second five years of the simulation and averaged 29.9 inches in those five years with the amount declining each year. Groundwater use increased substantially from the first to the second year, remained high for four years, and then decreased. Two factors defined this pattern in the simulation. First, gulf cordgrass biomass more than tripled over the 10-year simulation, increasing from 281 g/m$^2$ to 930 g/m$^2$ in the ungrazed scenario. This is total aboveground biomass. Clippable biomass in Year 10 would be about 558 g/m$^2$, which is very near the value (543 g/m$^2$) reported for an ungrazed gulf cordgrass community on the nearby Welder Wildlife Refuge (Garza et al. 1994). Gulf cordgrass is the dominant species on the salty bottomland site and its increase in biomass would therefore increase the ET of the community substantially. Secondly, huisache was abundant on the site. The presence of this woody species would also have contributed to a high ET, which was sustained on this site by shallow groundwater. Over the ten years of the simulation, the high productivity of both the gulf cordgrass and huisache effectively dewatered the soil profile above the water table, thereby resulting in a decrease in productivity, although standing crop biomass remained high, and a corresponding decrease in both ET and groundwater use. Reestablishment of trees on previously cleared areas can result in decreases in the water table (increase in DTW) as much as 5.5 m (18 feet) within 10 years (Bari and Schofield 1992).

Numerous literature studies have shown that groundwater use by most species decreases as rainfall-supplied soil moisture increases (see p. 61). Consequently, groundwater use by vegetation tends to decrease in wet years and increase in dry years. This pattern was clearly evidenced in the simulations, both in annual variability in rainfall under the moderate regime (Table 8.9) and in comparisons among dry, moderate, and wet regimes (Table 8.10). The moderate rainfall regime (Table 8.9) contained four years with relatively dry years (< 34 inches) and four years with relatively wet years (> 39 inches). Excluding the salty bottomland because of the effect of the increase in biomass in that type, groundwater use in the remaining five types averaged 12.52 inches in the four dry years and 7.82 in the four wet years, a decrease of 38% in groundwater use in wet years. Comparing the three regimes (dry, moderate, wet), groundwater use for the five types averaged 10.22 inches under the dry regime, 9.59 inches under the moderate regime, and 8.67 inches under the wet regime (Table 8.10).

**Table 8.10 Mean annual rainfall (inches), evapotranspiration (ET, inches) and groundwater use (GW) under three rainfall regimes for six vegetation types used in the calibration simulations for the Victoria County EDYS model. Values are means over 10 years used in each of the three simulations.**

| Regime | Rainfall | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ET | GW | ET | GW | ET | GW | ET | GW | ET | GW | ET | GW |
| Dry | 26.84 | 27.78 | 3.42 | 25.43 | 1.50 | 29.26 | 4.74 | 31.02 | 5.75 | 59.00 | 35.70 | 44.97 | 21.95 |
| Moderate | 36.74 | 35.31 | 3.29 | 33.20 | 2.02 | 35.81 | 3.14 | 40.01 | 6.25 | 63.19 | 33.24 | 89.28 | 58.39 |
| Wet | 44.99 | 42.53 | 2.71 | 40.48 | 1.86 | 43.92 | 3.01 | 49.66 | 7.29 | 65.31 | 28.49 | 65.89 | 28.80 |

Groundwater use in the salty bottomland type also reflected this shift from groundwater-use to rainfall-recharged soil moisture as conditions shifted from drier to wetter over the ten-year simulation. In the first four years of the simulation, groundwater supplied 85% of the transpirational water used by the two dominant species (huisache and gulf cordgrass). This allowed for high productivity (new growth) even though these years were relatively dry. During the last five years of the simulation, when rainfall was above average, groundwater supplied only 37% of the water used by huisache and gulf cordgrass. In addition, productivity (new growth) was relatively low during these last five years, although standing crop biomass (including old biomass such as trunks and stems) remained high.

### 8.2.2 Surface Runoff

Surface runoff (overland flow) occurs when the rate at which the supply of water exceeds the infiltration rate of the soil. This most commonly occurs during intense rainfall events or when soils become saturated because of an extended rainfall period. As runoff water flows downslope, it can increase in quantity as runoff water from adjacent locations is added to the flow or the quantity can decrease if the runoff water flows across drier soil or a fractured surface. In addition to the supply rate of incoming water, the amount of runoff is affected by slope (as slope increases, amount of runoff increases), soil texture (related to infiltration rate), and surface roughness. Surface roughness refers to the microtopography of the soil surface, including the presence of objects at the soil surface (e.g., rocks, litter, and plant stems, crowns, and trunks). Other factors held constant, runoff decreases as surface roughness increases.

There are both spatial and temporal aspects to runoff dynamics. Runoff changes spatially across a landscape in response to differences in topography and soils. Ockerman (2002) reported runoff from a loamy sand range site and a nearby clay range site on the Welder Wildlife Refuge. Both sites received approximately the same amount and intensity of rainfall at the same dates. Surface runoff averaged 2.7 inches/year on the loamy sand site but only 0.6 inch/year on the clay site. Wright et al. (1976) reported runoff from adjacent sites on the northern edge of the Edwards Plateau, one site with 3% slope and one with 13% slope. Runoff averaged 0.5 inch/year on the 3% slope and 2.7 inches on the 13% slope.

Temporal changes in runoff occur for a variety of reasons. Intensity of the rainfall event is a primary factor influencing the amount of runoff from a site. Most rainfall events do not result in measurable runoff. Along the central Texas Coast, rainfall events measuring less than two inches generally do not result in runoff (Ockerman and Petri 2001; Ockerman 2002) and in the Edwards Plateau the threshold level is about 0.7 inch (Thurow et al. 1988). In San Patricio County, there were only nine runoff events recorded over a two-year period and five of these were minor (0.07 inch or less; Ockerman 2002). Even at the lower threshold level in the Edwards Plateau (0.7 inch), there was an average of only nine runoff events per year over a six-year period (Thurow et al. 1988).

Amount of runoff is also affected by antecendent soil moisture conditions. A specific rainfall event is likely to result in much different runoff amounts when the event occurs following a dry period than when the soil is near field capacity. A 4.7-inch rainfall event in October 2000 resulted in less than 0.02 inch of runoff at a site in San Patricio County, compared to 0.34 inch of runoff from a 4.2-inch rain in November of the following year (Ockerman 2002). The October 2000 event was preceded by a very dry period and the November 2001 event occurred 10 weeks after a 7.5-inch rainfall event. A 4.6-inch rainfall event in early October 1998 resulted in 1.0 inch of runoff from an agricultural watershed in Kleberg and Nueces Counties in South Texas and a 5.5-inch rainfall event later that month produced 2.7 inches of runoff from the same, but now rain-soaked, watershed (Ockerman and Petri 2001).

A third important factor affecting landscape-level runoff dynamics is vegetation, and vegetation is itself dynamic. Carlson et al. (1990) compared runoff from nearby locations in the Rolling Plains of Texas where the vegetation had been manipulated. Annual runoff, averaged over three years, was 1.2 inches on sites with mesquite overstory plus a grass understory, 0.4 inch where the mesquite had been removed but the grasses remained, and 3.8 inches where both mesquite and grasses were removed. Grazing management can also have a substantial impact on runoff. Runoff on the Sonora Experiment Station located on the western edge of the Edwards Plateau averaged 2.9% of annual precipitation on a continuously-grazed pasture and 3.5% on a nearby site grazed under a four-pasture rotation system (Thurow et al. 1988). Both sites were moderately-stocked. Brush control methods can also affect amount of runoff. Wright et al. (1976) measured runoff on plots in the northern Edwards Plateau that had been previously bulldozed to reduce juniper density. Plots that were burned to remove the juniper slash and regrowth had 10% less runoff than on plots where the slash and regrowth had not been removed.

#### 8.2.2.1 Blackland Type

Simulated annual runoff varied between 0.1 and 7.2 inches on the blackland plot type (Table 8.11). Annual runoff averaged 4.0 inches for this type in the simulations, compared to 0.6 inch on a gauged clay rangeland watershed on the Welder Wildlife Refuge over a two-year period (Ockerman 2002). Annual rainfall averaged 30.9 inches over the two years included in the study on Welder Wildlife Refuge, compared to an annual average of 36.7 inches in the 10-year simulation. The third year of the simulation had 30.85 inches of rainfall, the same amount as the annual average in the Ockerman (2002) study, and the simulated runoff that year was 0.3 inch (Table 8.11).

**Table 8.11 Annual rainfall (inches), surface runoff (inches), and ratio of runoff to rainfall (RO/PPT) on the four upland types in the 10-year baseline calibration simulation, Victoria County EDYS model.**

| Rainfall Year | Rainfall | Blackland Runoff | Blackland RO/PPT | Claypan Prairie Runoff | Claypan Prairie RO/PPT | Loamy Prairie Runoff | Loamy Prairie RO/PPT | Sandy Loam Runoff | Sandy Loam RO/PPT |
|---|---|---|---|---|---|---|---|---|---|
| 1963 | 22.05 | 0.05 | 0.002 | 0.42 | 0.019 | 0.05 | 0.002 | 0.00 | 0.000 |
| 1964 | 33.30 | 2.64 | 0.079 | 3.38 | 0.102 | 2.10 | 0.063 | 0.56 | 0.017 |
| 1965 | 30.85 | 0.81 | 0.026 | 1.56 | 0.051 | 0.37 | 0.012 | 0.00 | 0.000 |
| 1966 | 35.44 | 3.30 | 0.093 | 4.11 | 0.116 | 2.61 | 0.074 | 1.02 | 0.029 |
| 1967 | 33.88 | 7.17 | 0.212 | 8.68 | 0.256 | 6.55 | 0.193 | 5.39 | 0.159 |
| 1968 | 49.29 | 6.16 | 0.125 | 7.52 | 0.153 | 4.44 | 0.090 | 2.69 | 0.055 |
| 1969 | 44.61 | 5.97 | 0.134 | 7.25 | 0.163 | 4.82 | 0.108 | 2.83 | 0.063 |
| 1970 | 39.76 | 4.46 | 0.112 | 5.91 | 0.149 | 3.61 | 0.091 | 2.65 | 0.067 |
| 1971 | 36.04 | 3.98 | 0.110 | 5.26 | 0.146 | 3.54 | 0.097 | 2.29 | 0.063 |
| 1972 | 42.14 | 5.64 | 0.134 | 7.05 | 0.167 | 5.21 | 0.124 | 3.66 | 0.087 |
| MEAN | 36.74 | 4.02 | 0.109 | 5.11 | 0.139 | 3.33 | 0.091 | 2.11 | 0.057 |

The ratio of annual runoff to annual rainfall in the simulations varied from 0.002 to 0.212 on the blackland type in the simulations and averaged 0.109 (10.9% of annual rainfall; Table 8.11). This is higher than values reported in the literature for vegetated sites in San Patricio County and in drier areas of Texas (Table 8.12). However, the ratio in the first three years of the simulation, when the amount of rainfall was more similar to those for the sites in Table 8.12, averaged 0.036 which was in close agreement with the reported values from the other locations. The data in Table 8.12 from Carlson et al. (1990) is an average of three years, and in one of years the ratio was 0.081 for the mesquite-grassland location, and rainfall for that year was 30.3 inches which is substantially less than the annual average of 36.7 inches used in the Victoria County EDYS calibrations. Data are also available over 17 years for a USGS gauge station on the Escondido Creek in Karnes County (Booker and McLendon 2016). The runoff/annual rainfall ratio at that station was 0.085-0.113 in five of the 17 years. Therefore, an annual ratio of 0.11 does not seem unreasonable for the higher rainfall area of Victoria County.

### 8.2.2.2 Other Types

Simulated average annual runoff was 2.1 inches on the sandy loam type, 3.3 inches on the loamy prairie, and 5.1 inches on the claypan prairie (Table 8.11). Annual average runoff/rainfall ratios for these three upland types were 0.057, 0.091, and 0.139, respectively. Like the values for the blackland type, these three values are higher than those reported in Table 8.12. However, the higher rainfall received in Victoria County likely results in higher runoff than under the lower rainfall of the Table 8.12. For example, the runoff/rainfall ratio on a woodland site in New South Wales, Australia, more than doubled in years when rainfall was 35-44 inches per year over years in which rainfall was 22-32 inches (0.292 and 0.120, respectively; Putuhena and Cordery 2000).

**Table 8.12 Examples of average annual runoff values (inches) in Texas reported in the literature, with corresponding runoff:precipitation ratios (RO/PPT).**

| Vegetation Type | Location | Runoff | RO/PPT | Reference |
|---|---|---|---|---|
| Mesquite-grassland | Rolling Plains | 1.22 | 0.042(0.021-0.081) | Carlson et al. 1990 |
| Grassland (mesquite removed) | Rolling Plains | 0.43 | 0.015(0.004-0.036) | Carlson et al. 1990 |
| Bare soil | Rolling Plains | 3.82 | 0.141(0.087-0.195) | Carlson et al. 1990 |
| Grassland, nearly level | N Edwards Plateau | 0.24 | 0.008 | Wright et al. 1976 |
| Grassland, 13% slope | N Edwards Plateau | 1.10 | 0.039 | Wright et al. 1976 |
| Oak-mixed grass (HILF) | W Edwards Plateau | ---- | 0.050 | Thurow et al. 1988 |
| Oak-mixed grass (4-pasture) | W Edwards Plateau | ---- | 0.035 | Thurow et al. 1988 |
| Oak-mixed grass (continuous) | W Edwards Plateau | ---- | 0.029 | Thurow et al. 1988 |
| Rangeland + cultivated | San Patricio Co. | 2.40 | 0.039(0.001-0.148) | Ockerman 2002 |
| Loamy sand rangeland | San Patricio Co. | 2.56 | 0.041(0.000-0.174) | Ockerman 2002 |
| Clay rangeland | San Patricio Co. | 0.63 | 0.011(0.000-0.042) | Ockerman 2002 |
| Cultivated (PPT = 12.9 in) | Kleberg-Nueces Cos. | 0.04 | 0.004(0.000-0.042) | Ockerman & Petri 2001 |
| Cultivated (PPT = 26.7 in) | Kleberg-Nueces Cos. | 4.06 | 0.152(0.012-0.488) | Ockerman & Petri 2001 |
| Cultivated (PPT = 38.1 in) | Kleberg-Nueces Cos. | 6.38 | 0.167(0.003-0.502) | Ockerman & Petri 2001 |

RO/PPT values outside parentheses are annual mean, values inside parentheses are ranges for individual PPT events.
HILF = high-intensity low-frequency grazing system; 4-pasture = 4-pasture rotation grazing system.

Runoff on the loamy bottomland type was the highest of all six types, averaging 6.3 inches per year and 17% of annual rainfall (Table 8.13). A major reason for the high rate on this type was spatial location. Much of the runoff from the upland sites moved across this type before entering streams and rivers, adding to the amount of rainfall received. Runoff on the salty bottomland type was less than on the loamy bottomland type, averaging 5.0 inches per year and 13.6% of annual rainfall (Table 8.13), but was higher than most of the upland types (Table 8.11). The salty bottomland type, like the loamy bottomland type, was located in the floodplain below the upland types. However, the salty bottomland type had a dense stand of gulf cordgrass which slowed runoff water and allowed more to infiltrate.

**Table 8.13 Annual rainfall (inches), surface runoff (inches), and ratio of runoff to rainfall (RO/PPT) on the two lowland types and the averages of the four upland types in the 10-year baseline calibration simulation, Victoria County EDYS model.**

| Rainfall Year | Rainfall | Loamy Bottomland Runoff | Loamy Bottomland RO/PPT | Salty Bottomland Runoff | Salty Bottomland RO/PPT | Upland Types Runoff | Upland Types RO/PPT |
|---|---|---|---|---|---|---|---|
| 1963 | 22.05 | 0.77 | 0.035 | 0.43 | 0.019 | 0.13 | 0.006 |
| 1964 | 33.30 | 4.13 | 0.124 | 3.47 | 0.104 | 2.17 | 0.065 |
| 1965 | 30.85 | 2.40 | 0.078 | 1.23 | 0.040 | 0.69 | 0.022 |
| 1966 | 35.44 | 4.78 | 0.135 | 3.09 | 0.087 | 2.76 | 0.078 |
| 1967 | 33.88 | 9.90 | 0.292 | 8.06 | 0.238 | 6.94 | 0.205 |
| 1968 | 49.29 | 8.54 | 0.174 | 5.53 | 0.112 | 5.20 | 0.106 |
| 1969 | 44.61 | 9.11 | 0.204 | 7.58 | 0.170 | 5.22 | 0.117 |
| 1970 | 39.76 | 7.79 | 0.196 | 5.71 | 0.144 | 4.16 | 0.105 |
| 1971 | 36.04 | 6.57 | 0.182 | 5.27 | 0.146 | 3.77 | 0.104 |
| 1972 | 42.14 | 9.13 | 0.217 | 9.66 | 0.229 | 5.39 | 0.128 |
| MEAN | 36.74 | 6.31 | 0.172 | 5.00 | 0.136 | 3.64 | 0.099 |

In summary, the runoff values in the simulations corresponded well with measured values from similar sites in Texas, especially sites in South Texas. These results indicate that the EDYS runoff values, both amount and proportional to rainfall, are reasonable.

### 8.2.3 Sediment Loadings

The amount of sediments transported in runoff water is of major importance in watershed management. Sediment loadings tend to increase as the amount and intensity of rainfall events increase and as surface roughness, especially vegetation cover, decreases. For example, typical sediment loadings at the Sonora Experiment Station are 25-50 $g/m^2/yr$ (Thurow et al. 1988), but following a high-intensity event (0.8 inch in 30 minutes) increased to 387 $g/m^2/yr$ (McCalla et al. 1984), a ten-fold increase. Similarly, annual sediment loadings on a mesquite-grassland in the Rolling Plains of Texas averaged 140 $g/m^2$ compared to 2,337 $g/m^2$ on nearby bare soil (Carlson et al. 1990).

Type, as well as amount, of vegetation cover also affects the amount of sedimentation. Grass cover tends to decrease both soil erosion (dislodging of soil particles) and sediment transport (movement of water-borne particles), compared to cover by woody species. Mesquite-grasslands in the Rolling Plains had annual sediment loadings of 140 $g/m^2$ compared to 25 $g/m^2$ on adjacent grassland sites where the mesquite had been removed. Sediment loadings on sites at the Sonora Experiment Station supporting midgrasses (e.g., sideoats grama and bluestems) were 40-78% less than the loadings on adjacent sites supporting shortgrasses [e.g., curly mesquite (*Hilaria belangeri*) and hairy grama (*Bouteloua hirsuta*); Knight et al. 1984, McCalla et al. 1984) and sediment loadings under live oak mottes were 93% less than loadings on midgrass sites (Knight et al. 1984).

Typical sediment loadings from rangelands in Texas vary between about 2 and 140 $g/m^2/yr$, or an equivalent of 0.03-2.13 $g/m^2/cm$ of annual precipitation (Table 8.14). A sediment loading of 2 $g/m^2/yr$ is equivalent to about 5 $g/m^2/inch$ of rainfall or about 50 lbs/ac/inch of rainfall.

**Table 8.14 Examples of measured sediment loadings on sites in Texas.**

| Vegetation | Location | Amount ($g/m^2/yr$) | Sediments/Rainfall ($g/m^2/cm$ PPT) | Reference |
|---|---|---|---|---|
| Rangeland, sandy soil | San Patricio County | 1.9 | 0.02 | Ockerman 2002 |
| Rangeland, clay soil | San Patricio County | 3.6 | 0.04 | Ockerman 2002 |
| Oak-mixed grass (rotation) | W Edwards Plateau | 41 | 0.74 | Thurow et al. 1988 |
| Oak-mixed grass (continuous) | W Edwards Plateau | 25 | 0.45 | Thurow et al. 1988 |
| Grassland (level, unburned) | N Edwards Plateau | 2 | 0.03 | Wright et al. 1976 |
| Grassland (level, burned) | N Edwards Plateau | 2 | 0.03 | Wright et al. 1976 |
| Grassland (13% slope unburned) | N Edwards Plateau | 17 | 0.23 | Wright et al. 1976 |
| Grassland (18% slope, burned) | N Edwards Plateau | 51 | 0.61 | Wright et al. 1976 |
| Mesquite-grassland | Rolling Plains | 140 | 2.13 | Carlson et al. 1990 |
| Grassland (mesquite removed) | Rolling Plains | 25 | 0.38 | Carlson et al. 1990 |
| Bare soil | Rolling Plains | 2337 | 35.52 | Carlson et al. 1990 |

The values in Table 8.14 were derived from studies using relatively small plots. Both runoff and sediment transport are less over longer distances, such as the landscapes simulated in the Victoria County model, because of vegetation patches and other heterogeneous features across the landscape that slow water movement thereby increasing infiltration and reducing the sediment load. Landscape-level sediment loads can be as low as 40% of plot-level loads (Ludwig et al. 2005). Annual sediment loadings, averaged over the entire county and over the 25-year simulation period under the moderate rainfall regime, were less than 0.1 g/m$^2$ (0.9 lb/acre). Even considering landscape-level processes in the model, this is likely too low a value. Adjusting the data for Ockerman (2002) in Table 8.14 to account for larger landscapes suggests an average sediment load on the order of 0.8-1.0 g/m$^2$/yr. Although sedimentation is likely to be less in Victoria than in most locations in Texas because of the relatively flat topography and predominance of clay and clay loam soils, 0.1 g/m$^2$/yr is probably an order of magnitude too low.

### 8.2.4 Flow Rates

There are seven USGS gauge stations in Victoria County (Fig. 8.1). Two of these, Placedo (8164800) and Garcitas (8164600), are on watersheds almost entirely within Victoria County (a small part of the Garcitas watershed lies in DeWitt County). Data from these two gauge stations were used for calibration purposes because of their locations within Victoria County.

A five-year data set (1999-2003) was used for each of these two gauge stations. The USGS data available for these stations were daily flows, which we summed into monthly totals (Table 8.15). Since these were internal watersheds, all flow at the gauge was assumed to have originated within the specific watershed. This water would include surface runoff from rain events, baseflow (subsurface lateral movement of infiltration water from rainfall via seeps and other possible locations of high groundwater), and anthropogenic discharges minus channel-loss and anthropogenic removals.

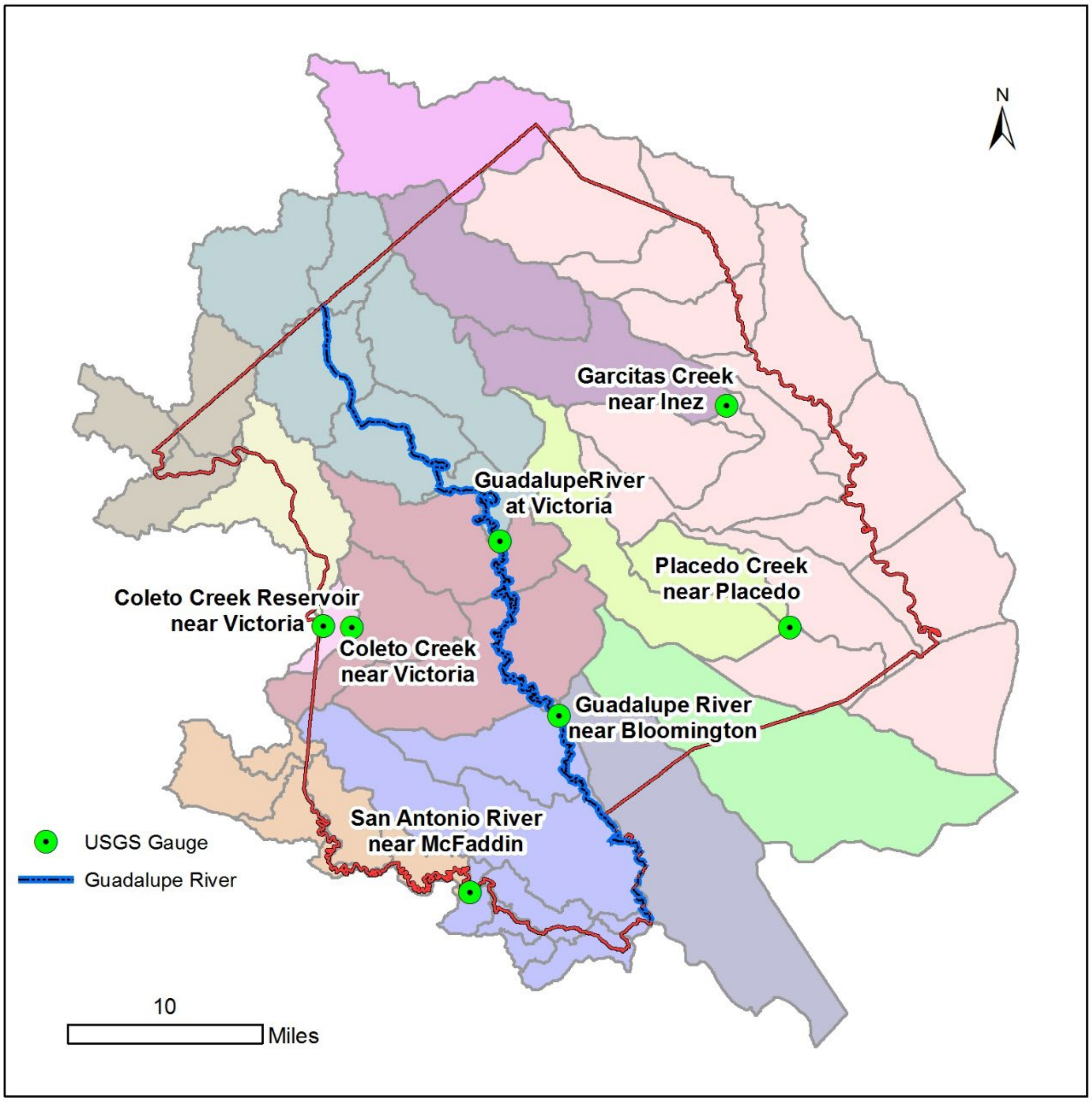


**Figure 8.1 Locations of the USGS gauge stations and their associated watersheds in Victoria County.**

**Table 8.15 Monthly flow (m³) at two USGS gauges in Victoria County, January 1999-December 2003, monthly rainfall (inches) at Victoria, and corresponding rainfall volume (m³) per watershed.**

| Month | Rainfall | Placedo Watershed | | | Garcitas Watershed | | |
|---|---|---|---|---|---|---|---|
| | (inches) | Rainfall (m³) | Flow (m³) | Flow/Rainfall | Rainfall (m³) | Flow (m³) | Flow/Rainfall |
| Jan 1999 | 0.63 | 2,918,979 | 291,730 | 0.100 | 3,590,386 | 453,144 | 0.126 |
| Feb 1999 | 1.94 | 8,988,600 | 110,354 | 0.012 | 11,056,110 | 358,361 | 0.032 |
| Mar 1999 | 3.41 | 15,799,550 | 415,702 | 0.026 | 19,433,679 | 185,973 | 0.010 |
| Apr 1999 | 0.32 | 1,482,656 | 122,408 | 0.083 | 1,823,688 | 60,492 | 0.033 |
| May 1999 | 6.43 | 29,792,113 | 475,284 | 0.016 | 36,644,737 | 163,365 | 0.004 |
| Jun 1999 | 4.83 | 22,378,834 | 1,302,464 | 0.058 | 27,526,296 | 996,127 | 0.036 |
| Jul 1999 | 2.19 | 10,146,925 | 549,262 | 0.054 | 12,500,867 | 234,377 | 0.019 |
| Aug 1999 | 0.98 | 4,540,633 | 59,544 | 0.013 | 5,585,045 | 10,066 | 0.002 |
| Sep 1999 | 3.78 | 17,513,870 | 137,810 | 0.008 | 21,542,318 | 23,164 | 0.001 |
| Oct 1999 | 1.15 | 5,328,294 | 31,708 | 0.006 | 6,553,880 | 12,682 | 0.002 |
| Nov 1999 | 0.33 | 1,528,989 | 19,168 | 0.013 | 1,880,679 | 120 | 0.000 |
| Dec 1999 | 1.02 | 4,725,965 | 23,989 | 0.005 | 5,813,007 | 11,959 | 0.002 |
| Jan 2000 | 3.73 | 17,282,206 | 296,872 | 0.017 | 21,257,367 | 63,048 | 0.003 |
| Feb 2000 | 0.69 | 3,196,976 | 150,893 | 0.047 | 3,932,328 | 40,153 | 0.010 |
| Mar 2000 | 2.16 | 10,007,926 | 302,868 | 0.030 | 12,309,896 | 370,486 | 0.030 |
| Apr 2000 | 2.96 | 13,714,565 | 820,482 | 0.060 | 16,769,117 | 3,572,793 | 0.213 |
| May 2000 | 7.88 | 36,510,396 | 3,170,350 | 0.087 | 44,910,324 | 2,505,332 | 0.055 |
| Jun 2000 | 4.42 | 20,479,182 | 1,991,930 | 0.097 | 25,191,027 | 6,535,631 | 0.259 |
| Jul 2000 | 0.88 | 4,077,303 | 39,802 | 0.010 | 5,017,139 | 53,312 | 0.010 |
| Aug 2000 | 0.94 | 4,355,301 | 9,414 | 0.002 | 5,355,311 | 4,927 | 0.001 |
| Sep 2000 | 1.47 | 6,810,950 | 2,231 | 0.000 | 8,376,782 | 90 | 0.000 |
| Oct 2000 | 4.49 | 20,803,513 | 76,078 | 0.004 | 25,590,181 | 245,682 | 0.010 |
| Nov 2000 | 5.21 | 24,139,493 | 5,149,914 | 0.213 | 29,692,593 | 3,758,167 | 0.127 |
| Dec 2000 | 1.93 | 8,942,267 | 421,229 | 0.047 | 10,998,899 | 1,911,775 | 0.174 |
| Jan 2001 | 2.60 | 12,046,577 | 4,604,465 | 0.382 | 14,819,577 | 5,289,596 | 0.357 |
| Feb 2001 | 0.44 | 2,038,652 | 39,717 | 0.019 | 2,505,798 | 249,348 | 0.010 |
| Mar 2001 | 3.75 | 17,374,871 | 313,284 | 0.018 | 21,371,349 | 994,605 | 0.047 |
| Apr 2001 | 0.17 | 787,661 | 56,520 | 0.072 | 970,165 | 98,735 | 0.102 |
| May 2001 | 6.01 | 27,846,127 | 2,427,748 | 0.087 | 34,249,586 | 1,296,951 | 0.038 |
| Jun 2001 | 0.42 | 1,945,986 | 15,955 | 0.007 | 2,394,922 | 14,225 | 0.006 |
| Jul 2001 | 1.20 | 5,559,959 | 14,292 | 0.003 | 6,841,049 | 239 | 0.000 |
| Aug 2001 | 8.97 | 41,560,692 | 6,625,118 | 0.159 | 51,119,380 | 6,725,965 | 0.132 |
| Sep 2001 | 7.06 | 32,711,091 | 13,393,464 | 0.409 | 40,226,900 | 27,148,608 | 0.675 |
| Oct 2001 | 4.81 | 22,286,168 | 4,479,679 | 0.200 | 27,414,091 | 2,935,524 | 0.107 |
| Nov 2001 | 3.82 | 17,699,202 | 8,048,134 | 0.455 | 21,770,503 | 6,186,396 | 0.284 |
| Dec 2001 | 3.52 | 16,309,212 | 5,812,970 | 0.356 | 20,063,012 | 13,207,362 | 0.658 |
| Jan 2002 | 0.53 | 2,455,648 | 164,472 | 0.067 | 3,021,371 | 219,487 | 0.072 |
| Feb 2002 | 0.33 | 1,528,989 | 61,760 | 0.040 | 1,879,348 | 141,025 | 0.075 |
| Mar 2002 | 0.46 | 2,131,318 | 52,853 | 0.025 | 2,722,217 | 119,741 | 0.044 |
| Apr 2002 | 3.90 | 18,069,866 | 1,875,438 | 0.104 | 23,230,638 | 2,296,919 | 0.099 |
| May 2002 | 2.02 | 9,359,264 | 51,484 | 0.006 | 11,514,473 | 28,591 | 0.003 |
| Jun 2002 | 5.04 | 23,351,827 | 1,014,022 | 0.043 | 28,722,428 | 210,376 | 0.007 |
| Jul 2002 | 5.48 | 25,390,479 | 11,001,454 | 0.433 | 33,228,225 | 20,640,776 | 0.621 |
| Aug 2002 | 2.58 | 11,953,912 | 113,356 | 0.009 | 14,702,158 | 141,482 | 0.010 |
| Sep 2002 | 3.93 | 18,208,865 | 2,342,808 | 0.128 | 22,396,952 | 433,662 | 0.019 |
| Oct 2002 | 8.55 | 39,614,707 | 21,555,097 | 0.544 | 48,724,458 | 8,743,811 | 0.179 |
| Nov 2002 | 3.70 | 17,143,317 | 21,119,436 | 1.232 | 22,088,615 | 15,417,266 | 0.698 |
| Dec 2002 | 2.61 | 12,092,910 | 4,529,869 | 0.375 | 14,874,015 | 4,121,592 | 0.277 |
| Jan 2003 | 2.04 | 9,451,930 | 2,338,854 | 0.247 | 11,625,349 | 5,941,824 | 0.511 |
| Feb 2003 | 1.65 | 7,644,943 | 1,662,872 | 0.218 | 9,402,285 | 821,847 | 0.087 |
| Mar 2003 | 1.09 | 5,050,296 | 628,924 | 0.125 | 6,214,600 | 306,741 | 0.049 |
| Apr 2003 | 0.26 | 1,204,658 | 168,428 | 0.140 | 1,480,195 | 195,875 | 0.132 |
| May 2003 | 0.08 | 370,664 | 14,414 | 0.039 | 454,592 | 50,396 | 0.111 |
| Jun 2003 | 5.61 | 25,992,807 | 325,014 | 0.013 | 31,971,095 | 20,087 | 0.001 |
| Jul 2003 | 7.93 | 36,742,061 | 8,168,982 | 0.222 | 45,193,058 | 3,007,398 | 0.066 |
| Aug 2003 | 1.62 | 7,505,942 | 84,688 | 0.011 | 9,230,427 | 74,151 | 0.008 |
| Sep 2003 | 8.38 | 38,827,048 | 3,695,259 | 0.095 | 47,959,837 | 7,618,835 | 0.159 |
| Oct 2003 | 4.53 | 20,978,844 | 564,673 | 0.027 | 25,817,477 | 7,223,680 | 0.280 |
| Nov 2003 | 3.42 | 15,845,883 | 5,764,658 | 0.364 | 19,492,001 | 4,822,706 | 0.249 |
| Dec 2003 | 1.06 | 4,911,298 | 384,724 | 0.078 | 6,597,122 | 523,280 | 0.079 |
| TOTALS | 184.34 | 854,102,338 | 149,486,371 | 0.175 | 1,049,640,924 | 168,840,328 | 0.161 |

Placedo watershed = 45,071 acres; Garcitas watershed = 55,438 acres.

Summed over the four years, gauged flow was 17.5% of rainfall (recorded at Victoria) on the Placedo watershed and 16.1% of rainfall on the Garcitas watershed (Table 8.15). In general, flow increased as rainfall increased and decreased as rainfall decreased (Figs. 8.2 and 8.3). However, the ratio between monthly flow and monthly rainfall varied considerably. There were 17 months where the monthly amount of rain received in the Placedo watershed exceeded 20 million $m^3$. Flow in these 17 months varied between 76,078 and 21,555,097 $m^3$ per month (0.4% and 54.4% of monthly rainfall, respectively). There were 16 months in which monthly rain was between 10-20 million $m^3$ and flow varied in these months between 113,356 and 21,119,436 $m^3$ (0.9% and 123.2% of monthly rainfall, respectively). The highest monthly flow in these 16 months (November 2002) followed a very wet month (October 2002), which partially explains the high flow value. However, there were four other months during the four years with high rainfall (7.9-9.0 inches) and the months following these four months had flow:rainfall ratios of less than 9%, except for September 2001 which also had high rainfall (7.1 inches). The Garcitas watershed also had similar variability in the relationship between amount of rain received and amount of gauged flow (Table 8.15).

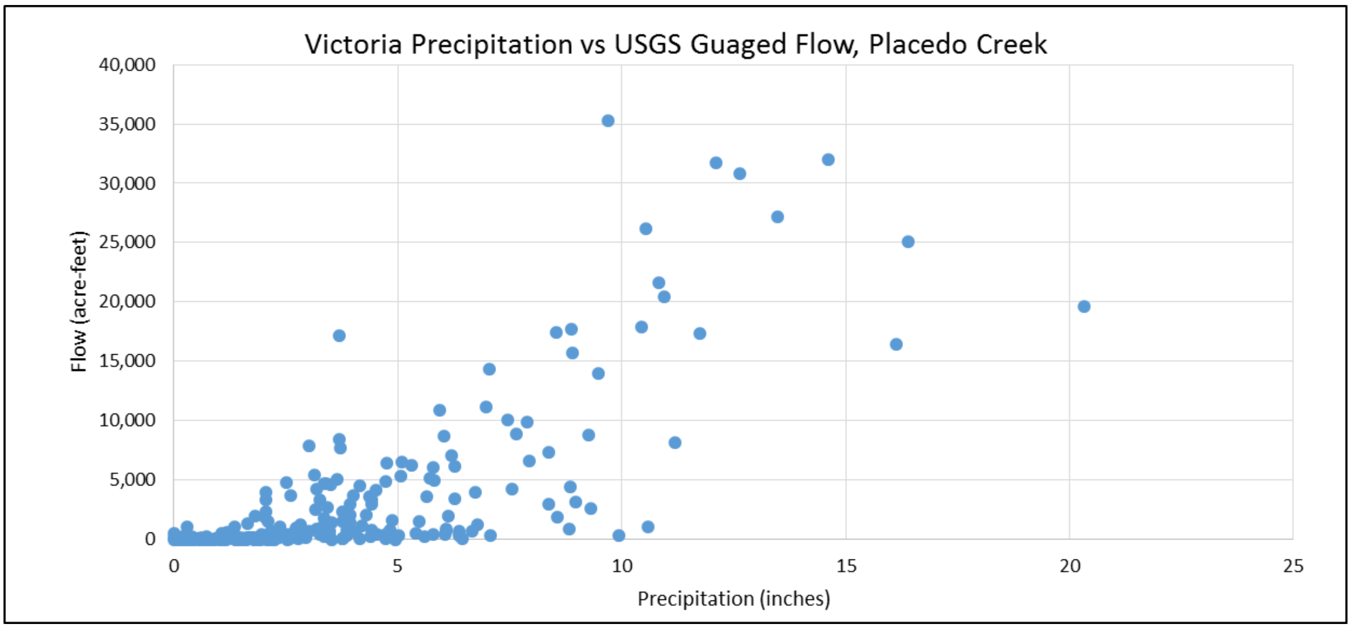


**Figure 8.2 Relationship between monthly flow (acre-feet) and monthly rainfall (inches) at the USGS Placedo gauge station, 1999-2003. Rainfall data are for the Victoria airport.**

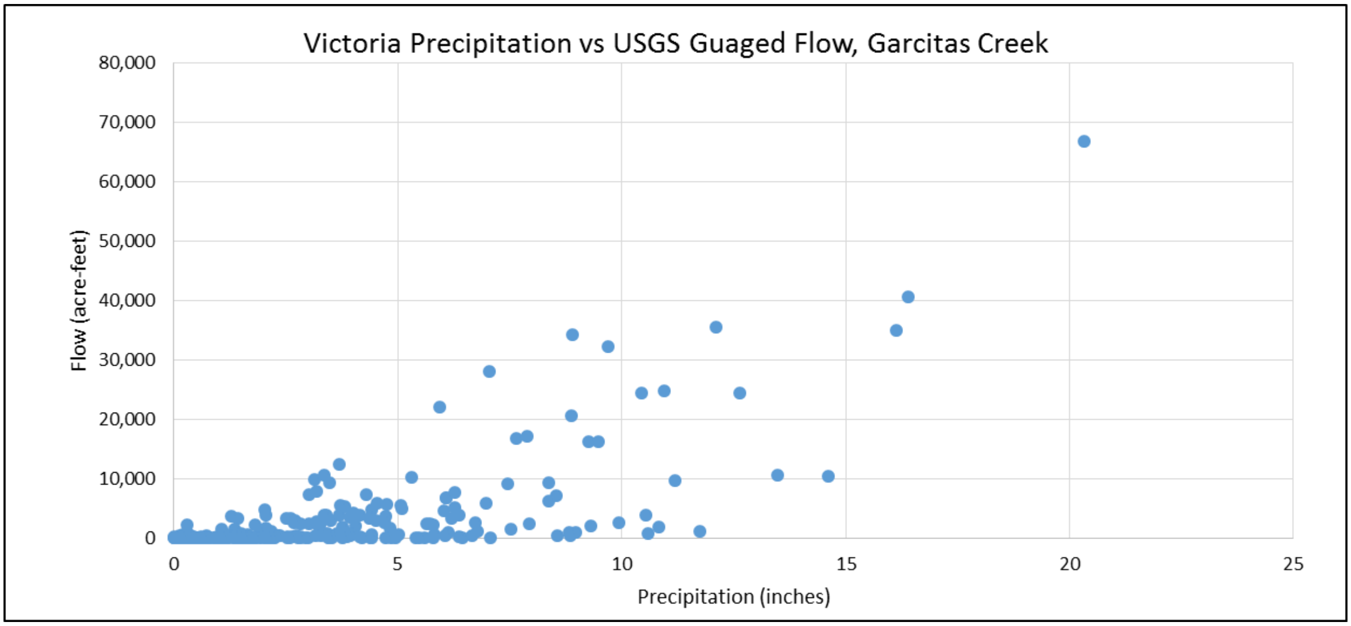


**Figure 8.3 Relationship between monthly flow (acre-feet) and monthly rainfall (inches) at the USGS Garcitas gauge station, 1999-2003. Rainfall data are for the Victoria airport.**

The high variability in the flow:rainfall ratio in both the Placedo and Garcitas watersheds suggests that factors in addition to the amount of rainfall received controlled the flow rates. This was also indicated by the high average flow:rainfall ratio. With flow averaging 16-18% of rainfall over four-years and with high ET rates, these two confined watersheds appear to be receiving water from sources in addition to rainfall. These could be groundwater discharge into the streams, lateral vadose-zone flow from adjacent watersheds, or anthropogenic inputs. Whatever the sources, the flow rates are not closely correlated with rainfall. Linkage to a groundwater model, such as MODFLOW, would be necessary to investigate possible sources and quantify the magnitude of the associated inputs. EDYS and MODFLOW have been linked in other applications to investigate these relationships but such a linkage is not currently included in the Victoria EDYS model. Therefore flow rates cannot be directly used to calibrate EDYS simulated runoff.

Although USGS gauged streamflow cannot be used directly to calibrate EDYS simulated runoff in the Victoria County model, there is another source of USGS data that can be used to give at least a coarse calibration of the EDYS runoff values and also provide a first-approximation estimate, independent of EDYS values, of the amount of the gauged flow that is attributable to surface runoff. The USGS conducted a two-year study of surface runoff from three gauged watersheds in eastern San Patricio County (Ockerman 2002). The three gauged watersheds were 1) a clay rangeland 349-acre watershed, 2) a 97-acre loamy sand rangeland watershed, and 3) a 13,818-acre watershed consisting of 2,500 acres of cultivation, a highway segment, and the remainder a combination of sandy loam and loam rangeland. During the two-year study, the sites received 61.47 inches of rain, but runoff was recorded for only nine rainfall events (Table 8.16). The nine events had a total rainfall of 32.26 inches, or 52.5% of the total rainfall received. In general, a rainfall event needed to be more than two inches to produce measurable runoff on these watersheds (Ockerman 2002:6). For ease of comparison to the EDYS output, we converted the runoff data from Ockerman (2002) from acre-feet into $m^3$ and then into $m^3$ per acre (Table 8.16).

**Table 8.16 Surface runoff from three watersheds on the Welder Wildlife Refuge, San Patricio County (Ockerman 2002).**

| Date | Rainfall | Moody Creek | | Watershed 1 | | Watershed 2 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | (inches) | (acre-feet) | ($m^3$) | (acre-feet) | ($m^3$) | (acre-feet) | ($m^3$) | (acre-feet) | ($m^3$) |
| 13-16 Mar 2000 | 6.11 | 685 | 844,811 | 8.6 | 10,606 | 5.8 | 7,153 | 699 | 862,077 |
| 06 Oct 2000 | 4.67 | 19.4 | 23,926 | 0.8 | 987 | 0.0 | 0 | 20.2 | 24,913 |
| 10-12 Oct 2000 | 1.89 | 10.9 | 13,443 | 0.3 | 370 | 0.0 | 0 | 11.2 | 13,813 |
| 04-08 Nov 2000 | 2.53 | 36.2 | 44,645 | 1.1 | 1,357 | 0.6 | 740 | 37.9 | 46,742 |
| 16-19 Nov 2000 | 1.94 | 81.2 | 100,144 | 1.6 | 1,973 | 0.0 | 0 | 82.8 | 102,117 |
| 26 Dec 2000 | 0.88 | 1.7 | 2,097 | 0.0 | 0 | 0.0 | 0 | 1.7 | 2,097 |
| 10-20 Jan 2001 | 2.61 | 256 | 315,725 | 2.2 | 2,713 | 0.8 | 987 | 259 | 319,425 |
| 28-01 Sep 2001 | 7.46 | 1,270 | 1,566,291 | 7.6 | 9,373 | 9.2 | 11,346 | 1,290 | 1,590,957 |
| 16-17 Nov 2001 | 4.17 | 402 | 495,787 | 1.8 | 2,220 | 2.4 | 2,960 | 406 | 500,720 |
| Total (9 events) | 32.26 | 2,760 | | | | | | | |
| Total (all) | 61.47 | | | | | | | | |
| **Per acre values ($m^3$/acre)** | | | | | | | | | |
| 13-16 Mar 2000 | 6.11 | | 61.14 | | 109.34 | | 20.50 | | 60.44 |
| 06 Oct 2000 | 4.67 | | 1.73 | | 10.17 | | 0.00 | | 1.75 |
| 10-12 Oct 2000 | 1.89 | | 0.98 | | 3.81 | | 0.00 | | 0.97 |
| 04-08 Nov 2000 | 2.53 | | 3.23 | | 13.99 | | 2.12 | | 3.28 |
| 16-19 Nov 2000 | 1.94 | | 7.25 | | 20.34 | | 0.00 | | 7.16 |
| 26 Dec 2000 | 0.88 | | 0.15 | | 0.00 | | 0.00 | | 0.15 |
| 10-20 Jan 2001 | 2.61 | | 22.85 | | 27.97 | | 2.83 | | 22.39 |
| 28-01 Sep 2001 | 7.46 | | 113.35 | | 96.63 | | 32.51 | | 111.54 |
| 16-17 Nov 2001 | 4.17 | | 35.88 | | 22.89 | | 8.48 | | 35.10 |
| Total | 32.26 | | 246.35 | | 305.14 | | 66.44 | | 242.09 |

Moody Creek Watershed = 13,818 acres (11,318 ac rangeland, 2500 ac cultivated), sandy loam and loam soils. Watershed 1 = 97 acres loamy sand rangeland; Watershed 2 = 349 acres clay rangeland.

Total surface runoff simulated by EDYS over the five years was 28,902,726 $m^3$ for the Placedo watershed and 21,472,930 $m^3$ for the Garcitas watershed, or a combined total of 50,375,656 $m^3$ (Table 8.17). The Placedo watershed covers 45,071 acres and the Garcitas watershed 55,438 acres, for a combined total of 100,509 acres. For the entire five-year simulation, the average per acre runoff was 641.27 $m^3$ for the Placedo watershed and 387.33 $m^3$ for the Garcitas watershed. The total rainfall in the five-year simulation was 184.34 inches. This resulted in an average runoff of 3.48 $m^3$/acre/inch of rainfall for the Placedo watershed, 2.10 $m^3$/acre/inch of rainfall for the Garcitas watershed, and 2.72 $m^3$/acre/inch rainfall for the two watersheds combined (Table 8.18).

**Table 8.17 Monthly rainfall (inches; Victoria airport), EDYS simulated surface runoff ($m^3$), and USGS gauged flows ($m^3$) from the Placedo and Garcitas watersheds, Victoria County, 1999-2003.**

| Month | Rainfall | Placedo Watershed | | Garcitas Watershed | |
|---|---|---|---|---|---|
| | | EDYS Runoff | Gauged Flow | EDYS Runoff | Gauged Flow |
| Jan 1999 | 0.63 | 0 | 291,730 | 0 | 453,144 |
| Feb 1999 | 1.94 | 44 | 110,354 | 15 | 358,361 |
| Mar 1999 | 3.41 | 1,133,005 | 415,702 | 401,673 | 185,973 |
| Apr 1999 | 0.32 | 143 | 122,408 | 232 | 60,492 |
| May 1999 | 6.43 | 401,093 | 475,284 | 247,219 | 163,365 |
| Jun 1999 | 4.83 | 1,655,821 | 1,302,464 | 1,145,727 | 996,127 |
| Jul 1999 | 2.19 | 494 | 549,262 | 940 | 234,377 |
| Aug 1999 | 0.98 | 0 | 59,544 | 0 | 10,066 |
| Sep 1999 | 3.78 | 31 | 137,810 | 0 | 23,164 |
| Oct 1999 | 1.15 | 0 | 31,708 | 0 | 12,682 |
| Nov 1999 | 0.33 | 0 | 19,168 | 0 | 120 |
| Dec 1999 | 1.02 | 387 | 23,989 | 708 | 11,959 |
| Jan 2000 | 3.73 | 931,769 | 296,872 | 306,395 | 63,048 |
| Feb 2000 | 0.69 | 0 | 150,893 | 0 | 40,153 |
| Mar 2000 | 2.16 | 637,917 | 302,868 | 318,340 | 370,486 |
| Apr 2000 | 2.96 | 28,695 | 820,483 | 51,888 | 3,572,793 |
| May 2000 | 7.88 | 1,217,481 | 3,170,350 | 733,309 | 2,505,332 |
| Jun 2000 | 4.42 | 33,891 | 1,991,930 | 60,738 | 6,535,631 |
| Jul 2000 | 0.88 | 0 | 39,802 | 0 | 53,312 |
| Aug 2000 | 0.94 | 229 | 9,414 | 388 | 4,927 |
| Sep 2000 | 1.47 | 0 | 2,231 | 0 | 90 |
| Oct 2000 | 4.49 | 321 | 76,078 | 533 | 245,682 |
| Nov 2000 | 5.21 | 186,156 | 5,149,914 | 54,095 | 3,758,167 |
| Dec 2000 | 1.93 | 195 | 421,229 | 318 | 1,911,775 |
| Jan 2001 | 2.60 | 812,308 | 4,604,465 | 264,980 | 5,289,596 |
| Feb 2001 | 0.44 | 0 | 39,717 | 0 | 249,348 |
| Mar 2001 | 3.75 | 321 | 313,284 | 547 | 994,605 |
| Apr 2001 | 0.17 | 0 | 56,520 | 0 | 98,735 |
| May 2001 | 6.01 | 3,641,034 | 2,427,748 | 3,293,298 | 1,296,951 |
| Jun 2001 | 0.42 | 0 | 15,955 | 0 | 14,225 |
| Jul 2001 | 1.20 | 449 | 14,292 | 845 | 239 |
| Aug 2001 | 8.97 | 116,113 | 6,625,118 | 123,273 | 6,725,965 |
| Sep 2001 | 7.06 | 1,865,284 | 13,393,464 | 1,512,343 | 27,148,608 |
| Oct 2001 | 4.81 | 608,181 | 4,479,679 | 449,467 | 2,935,524 |
| Nov 2001 | 3.82 | 2,029,322 | 8,048,134 | 1,547,548 | 6,186,396 |
| Dec 2001 | 3.52 | 11,422 | 5,812,970 | 11,760 | 13,207,362 |
| Jan 2002 | 0.53 | 0 | 164,472 | 0 | 219,487 |
| Feb 2002 | 0.33 | 0 | 61,760 | 0 | 141,025 |
| Mar 2002 | 0.46 | 0 | 52,853 | 0 | 119,741 |
| Apr 2002 | 3.90 | 2,179,572 | 1,875,438 | 1,642,912 | 2,296,919 |
| May 2002 | 2.02 | 0 | 51,484 | 0 | 28,591 |
| Jun 2002 | 5.04 | 598,985 | 1,014,022 | 344,001 | 210,376 |
| Jul 2002 | 5.48 | 2,403,934 | 11,001,454 | 2,044,257 | 20,640,776 |
| Aug 2002 | 2.58 | 0 | 113,356 | 0 | 141,482 |
| Sep 2002 | 3.93 | 3,519,884 | 2,342,808 | 3,371,923 | 433,662 |
| Oct 2002 | 8.55 | 1,153,689 | 21,555,097 | 867,561 | 8,743,811 |
| Nov 2002 | 3.70 | 243,057 | 21,119,436 | 111,065 | 15,417,266 |
| Dec 2002 | 2.61 | 80,340 | 4,529,869 | 22,489 | 4,121,592 |
| Jan 2003 | 2.04 | 217,811 | 2,338,854 | 49,588 | 5,941,824 |
| Feb 2003 | 1.65 | 22 | 1,662,872 | 0 | 821,847 |
| Mar 2003 | 1.09 | 0 | 628,924 | 0 | 306,741 |
| Apr 2003 | 0.26 | 0 | 168,428 | 0 | 195,875 |
| May 2003 | 0.08 | 0 | 14,414 | 0 | 50,396 |
| Jun 2003 | 5.61 | 413,730 | 325,014 | 254,594 | 20,087 |
| Jul 2003 | 7.93 | 26,339 | 8,168,982 | 34,547 | 3,007,398 |
| Aug 2003 | 1.62 | 0 | 84,688 | 0 | 74,151 |
| Sep 2003 | 8.38 | 1,116,603 | 3,695,259 | 981,564 | 7,618,835 |
| Oct 2003 | 4.53 | 60,633 | 564,673 | 30,083 | 7,223,680 |
| Nov 2003 | 3.42 | 1,575,669 | 5,764,658 | 1,191,111 | 4,822,706 |
| Dec 2003 | 1.06 | 352 | 384,724 | 656 | 523,280 |
| TOTAL | 184.34 | 28,902,726 | 149,486,371 | 21,472,930 | 168,840,328 |

**Table 8.18 Summary of runoff calculations for the Placedo and Garcitas watersheds in Victoria County (EDYS simulations, 1999-2003) and comparsions with data from gauged watersheds in eastern San Patricio County (Table 8.16).**

| | EDYS Simulations | | | Gauged Data | | |
|---|---|---|---|---|---|---|
| | Placedo | Garcitas | Combined | Watershed 2 | Moody | Average |
| Total runoff ($m^3$) | 28,902,726 | 21,472,930 | 50,375,656 | 23,186 | 3,406,869 | |
| Area (acres) | 45,071 | 55,438 | 100,509 | 349 | 13,818 | |
| Per acre runoff ($m^3$) | 641.27 | 387.33 | 501.21 | 66.44 | 246.35 | |
| Total rainfall (inches) | 184.34 | 184.34 | 184.34 | 61.47 | 61.47 | |
| Runoff ($m^3$/acre/inch) | 3.48 | 2.10 | 2.72 | 1.08 | 4.01 | 2.55 |
| Total rainfall ($m^3$) | 854,102,338 | 1,049,640,924 | | 1,788 | 60,782 | |
| Runoff:Rainfall ratio | 0.034 | 0.020 | | 0.011 | 0.045 | |

Simulation data are over five years (1999-2003). Gauged data are for two years (2000-2001).

Soils of the Placedo watershed are predominantly clays and clay loams (Lake Charles and Dacosta series) and those of the Garcitas watershed are mostly sandy loams (Nada, Telferner, and Inez series) with some Garcitas loamy sands (Miller 1984). Soils of Watershed 2 (Table 8.18) are clays and those of the Moody watershed are sandy loams and loams. The average gauged runoff from the two watersheds in San Patricio County was 2.55 $m^3$/acre/inch of rainfall (Table 8.18). This compares very favorably with the EDYS simulated combined mean of 2.72 $m^3$/acre/inch of rainfall. The simulated runoff for the Placedo watershed is higher than the value for the clay-soil gauged watershed (Watershed 2) and the Garcitas watershed value is lower than the Moody watershed. These differences could be the result of EDYS calculations of runoff on clays vs. sandy loams or they could be differences in surface features between the Victoria County watersheds and the San Patricio County watersheds.

San Patricio County Watershed 2 received 1,787.8 acre-feet of rainfall over the two-year study and this resulted in 18.8 acre-feet of runoff (Table 8.16), or a runoff:rainfall ratio of 0.011 (1.1%). The Moody watershed received 60,782.7 acre-feet of rainfall and had 2,760 acre-feet of runoff, for a runoff:rainfall ratio of 0.045 (4.5%). These ratios compare favorably with those from other studies in Texas (Table 8.2). The ratios from the EDYS simulations, 0.034 for the Placedo watershed and 0.020 for the Garcitas watershed, are also similar, indicating that the Victoria EDYS model is producing realistic runoff values.

Measured flow at the Placedo gauge during 1999-2003 was equal to 17.5% of rainfall during the same period and at the Garcitas gauge it was 16.1% of rainfall (Table 8.15). The EDYS simulations of surface runoff provide a reasonable estimate of the contribution of surface runoff to flow or, conversely, how much of gauged flow appears to be from sources other than surface runoff. Averaged over the five years (1999-2003), simulated runoff from the Placedo watershed accounted for 19.3% of gauged flow and 12.7% of gauged flow from the Garcitas watershed (Table 8.17).

Flow is also affected by factors other than amount of rainfall received in a particular month or previous month. There is often a lag time between a rainfall event, or series of events, and flow being recorded at a gauge station. Flow is composed of both runoff and subsurface movement of water into the drainage. For example, 6.4 inches of rain fell in May 1999 and there was a moderate amount (475,284 $m^3$) of flow at the Placedo gauge (Table 8.17). The next month, there was less rain (4.8 inches) but three times as much flow. July 1999 had even less rain (2.2 inches) but flow was higher than in May when there was three times as much rainfall. In September 1999, there was 3.8 inches of rain but only one-third as much flow as in July when there was only 2.2 inches. The amount of flow in any one month is influenced by (in addition to other factors) rainfall received, surface runoff, available storage capacity in the vadose zone, and the amount of time it takes for water to move laterally through the particular soils in a watershed.

## 9.0 SCENARIOS

A scenario in EDYS consists of a specific simulation run. Each scenario is defined by a selection of inputs that can include any combination of precipitation, stressor, management, and time factors. The specific combination defining a scenario can be applied across the entire spatial footprint or can be localized. Ten scenarios were defined as examples to be included in this report. A 25-year simulation period was used for each of the 10 scenarios.

**1. Baseline.** No changes in land management options; daily precipitation data from 1962-1985 were used as most indicative of long-term average conditions (1898-2015 annual mean for Victoria = 36.91 inches; 1962-85 annual mean for Victoria = 36.82 inches).

**2. Dry Cycle.** No changes in land management options; daily precipitation data from 1932-1956; 1932-1956 were the driest 25 consecutive years on record for Victoria (annual mean = 32.10 inches = 0.870 of long-term mean).

**3. Wet Cycle.** No changes in land management options; daily precipitation data from 1983-2007 used; 1983-2007 were the wettest 25 consecutive years on record for Victoria (annual mean = 42.34 inches = 1.147 of long-term mean).

**4. Moderate Precipitation, Moderate Livestock Grazing.** Same as Scenario 1 except cattle grazing was included. Stocking rates were held constant (Appendix Table D.2).

**5. Moderate Precipitation, Heavy Livestock Grazing.** Same as Scenario 4 except stocking rates were increased by 50% over levels in Appendix Table D.2.

**6. Brush Management (Huisache), Average Rainfall and Moderate Grazing.** 90% of aboveground biomass of huisache removed in Year 1 on all non-urban areas; average rainfall pattern (1962-1985); moderate grazing by livestock maintained.

**7. Brush Management (Macartney rose), Average Rainfall and Moderate Grazing.** Same as Scenario 6 except 90% of Macartney rose removed instead of huisache.

**8. Brush Management (All Woody Species), Average Rainfall and Moderate Grazing.** 90% of aboveground biomass of all woody species, except only 50% of live oak, removed in Year 1 on all non-urban areas; average rainfall pattern (1962-1985); moderate grazing by livestock.

**9. Brush Management (All Woody Species), Dry Rainfall and Moderate Grazing.** Same as Scenario 8 except dry rainfall pattern (1932-1956) was applied.

**10. Brush Management (All Woody Species), Wet Rainfall and Moderate Grazing.** Same as Scenario 8 except wet rainfall pattern (1983-2007) was applied.

## 9.1 Vegetation

### 9.1.1 Baseline

#### 9.1.1.1 Blackland Type: 38% Initial Cover of Woody Species

Under baseline conditions (average rainfall over 25 years, no grazing by cattle), tree biomass increased by 50% after 15 years and more than doubled by the end of 25 years, with most of the increase coming from huisache (Table 9.1). Huisache biomass doubled at the end of 15 years and increased by another 50% by the end of 25 years. The 15-year increase in huisache was about twice the rate as reported at Welder Wildlife Refuge (46% in 16 years; Box et al. 1979). The slower rate of increase over the last 10 years of the simulation is reasonable for two reasons: 1) huisache is a mid-seral woody species and therefore its rate of increase decreases in the later stages of succession and 2) the canopy coverage of woody species (trees and shrubs) by Year 15 was approaching 50% (Appendix Table C.23) and open spaces for woody plant establishment were becoming more limited. Mesquite also increased, but at a slower rate than huisache (7% in first 15 years and an additional 8% over last 10 years). Although the rate of increase was slower than for huisache, the rate remained stable over the entire 25-year simulation. Mesquite is a later-seral species than huisache and therefore continues to increase over a longer successional period. The other two tree species in this type, sugar hackberry and live oak, occurred in lower amounts that either huisache or mesquite and both hackberry and live oak decreased in biomass over the 25-year simulation.

All three shrub species, including Macartney rose, decreased in this type over the 25-year simulation in response to competition from huisache. Total woody plant cover (trees and shrubs) increased by 17% over the first 15 years and by 43% (over initial conditions) by Year 25. This is less than the 71% increase in woody species over a 24-year period in the central part of the Coastal Bend (Archer et al. 1988).

Aboveground biomass of herbaceous species decreased by 24% over the first 15 years of the simulation and by 66% by Year 25, compared to initial conditions (Table 9.1). This decrease was in response to the increase in woody species, primarily huisache. Initial cover of woody species was 38%. This increased to 47% by Year 15 and 60% by Year 25. Huisache alone had 40% cover by Year 25. Based on data from the Welder Wildlife Refuge (Scrifes et al. 1982), an increase in woody plant cover from 38% to 47% would decrease herbaceous production by 15% and an increase from 38% to 60% would decrease production by 37%.

**Table 9.1 Aboveground biomass (g/m²), by lifeform and major species, in four upland plot types (38% initial cover of woody species) at the end of growing season in the first (01), fifteenth (15), and last (25) years of a 25-year simulation under the baseline scenario (average rainfall pattern, no livestock grazing), Victoria County EDYS model.**

| Lifeform/Species | Blackland | | | Claypan Prairie | | | Loamy Prairie | | | Sandy Loam | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 15 | 25 | 01 | 15 | 25 | 01 | 15 | 25 | 01 | 15 | 25 |
| Trees | 1677 | 2655 | 3549 | 1910 | 2531 | 3189 | 2894 | 3378 | 4118 | 4773 | 4477 | 4223 |
| Shrubs | 1183 | 694 | 544 | 1861 | 1163 | 931 | 807 | 436 | 340 | 289 | 235 | 177 |
| Midgrasses | 87 | 93 | 47 | 76 | 38 | 19 | 170 | 284 | 139 | 123 | 431 | 668 |
| Shortgrasses | 96 | 50 | 17 | 55 | 34 | 16 | 92 | 136 | 70 | 81 | 45 | 30 |
| Grass-likes | 11 | 17 | 3 | 18 | 26 | 8 | 5 | t | t | --- | --- | --- |
| Forbs | 60 | 34 | 20 | 36 | 8 | 4 | 65 | 11 | 4 | 46 | 265 | 71 |
| Total aboveground | 3114 | 3543 | 4180 | 3956 | 3800 | 4167 | 4033 | 4245 | 4671 | 5312 | 5453 | 5169 |
| Huisache | 888 | 1839 | 2700 | 731 | 1448 | 2157 | 728 | 1299 | 2121 | 116 | 107 | 99 |
| Sugar hackberry | 99 | 89 | 79 | --- | --- | --- | 248 | 223 | 201 | 248 | 212 | 187 |
| Mesquite | 587 | 631 | 678 | 147 | 125 | 113 | 886 | 887 | 866 | 1044 | 887 | 802 |
| Post oak | --- | --- | --- | --- | --- | --- | --- | --- | --- | 251 | 213 | 190 |
| Live oak | 103 | 96 | 92 | 1032 | 958 | 919 | 1032 | 969 | 930 | 3114 | 3058 | 2945 |
| Blackbrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | 97 | 56 | 40 |
| Baccharis | 157 | 88 | 67 | 202 | 138 | 108 | --- | --- | --- | --- | --- | --- |
| Granjeno | --- | --- | --- | --- | --- | --- | --- | --- | --- | 192 | 179 | 137 |
| Macartney rose | 998 | 573 | 458 | 1613 | 1017 | 820 | 807 | 436 | 340 | --- | --- | --- |
| Greenbriar | 28 | 33 | 19 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rattlepod | --- | --- | --- | 46 | 8 | 3 | --- | --- | --- | --- | --- | --- |
| Big bluestem | 1 | 1 | 1 | t | t | t | 1 | 2 | 2 | 1 | 2 | 7 |
| Bushy bluestem | 18 | 4 | 1 | 19 | 3 | 1 | 26 | 4 | 2 | --- | --- | --- |
| Silver bluestem | 9 | 8 | 6 | --- | --- | --- | --- | --- | --- | 13 | 6 | 4 |
| Sideoats grama | 2 | 3 | 2 | --- | --- | --- | --- | --- | --- | 2 | 22 | 86 |
| Panamerican balsamscale | --- | --- | --- | --- | --- | --- | --- | --- | --- | 37 | 36 | 16 |
| Plains lovegrass | --- | --- | --- | --- | --- | --- | 2 | 1 | t | 2 | 2 | 1 |
| Switchgrass | 2 | 2 | 1 | 1 | 1 | t | 2 | 1 | 1 | --- | --- | --- |
| Little bluestem | 29 | 30 | 15 | 41 | 22 | 11 | 112 | 204 | 94 | 53 | 325 | 518 |
| Plains bristlegrass | 2 | 1 | 1 | --- | --- | --- | --- | --- | --- | 10 | 30 | 28 |
| Indiangrass | 1 | 1 | 1 | 1 | 1 | t | 2 | 1 | 1 | 1 | 7 | 7 |
| Johnsongrass | 4 | 7 | 2 | --- | --- | --- | 9 | 35 | 15 | --- | --- | --- |
| Tall dropseed | 2 | 1 | 1 | 2 | 1 | 1 | --- | --- | --- | 3 | 1 | 1 |
| Smutgrass | 15 | 35 | 16 | 12 | 10 | 6 | 15 | 36 | 24 | --- | --- | --- |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | --- | --- | --- | 24 | 13 | 7 |
| Purple threeawn | 10 | 5 | 3 | --- | --- | --- | 3 | 1 | 1 | --- | --- | --- |
| Buffalograss | 26 | 7 | 1 | --- | --- | --- | --- | --- | --- | 8 | 1 | t |
| Sandbur | --- | --- | --- | --- | --- | --- | --- | --- | --- | 3 | 3 | 2 |
| Bermudagrass | 9 | 1 | t | 10 | 1 | t | 5 | 1 | t | 15 | 2 | 1 |
| Longtom | 9 | 3 | 2 | 14 | 5 | 3 | 15 | 5 | 3 | --- | --- | --- |
| Brownseed paspalum | 13 | 26 | 9 | 5 | 3 | 2 | 38 | 78 | 37 | 16 | 24 | 20 |
| Thin paspalum | 13 | 3 | 1 | 6 | 1 | t | 11 | 2 | 1 | 6 | 1 | t |
| Knotroot bristlegrass | 13 | 5 | 1 | 17 | 23 | 11 | 18 | 48 | 27 | 6 | 1 | t |
| Texas wintergrass | 3 | t | t | --- | --- | --- | 2 | 1 | 1 | 3 | t | t |
| Littletooth sedge | --- | --- | --- | 8 | 19 | 7 | 5 | t | t | --- | --- | --- |
| Flatsedge | 11 | 17 | 3 | 10 | 7 | 1 | --- | --- | --- | --- | --- | --- |
| Ragweed | 26 | 3 | t | 17 | 1 | t | 40 | 3 | t | 32 | 184 | 41 |
| Wild indigo | 10 | 5 | 3 | 14 | 7 | 4 | 10 | 6 | 3 | --- | --- | --- |
| Old-mans beard | 3 | 21 | 16 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Bundleflower | 1 | t | t | 2 | t | 0 | 3 | t | t | 1 | t | t |
| Frogfruit | 9 | t | t | 3 | t | t | --- | --- | --- | --- | --- | --- |
| Snoutbean | --- | --- | --- | --- | --- | --- | 2 | 1 | 1 | 2 | 0 | 0 |
| Bush sunflower | 9 | 5 | 1 | --- | --- | --- | 9 | 1 | t | 9 | 81 | 30 |

Dashes (---) indicate that the species was not included in the simulation for that type.
A trace amount (< 0.5 g/m²) is indicated with at "t".

Species composition also changed in the herbaceous component over the 25-year simulation. The major herbaceous species initially were little bluestem (11% relative biomass), buffalograss (10%), ragweed (10%), bushy bluestem (7%), and smutgrass (6%). Except for little bluestem, these are all early- or mid-seral species. By Year 25, the major species were smutgrass (18% relative biomass), old-man's beard (18%), little bluestem (17%), and brownseed paspalum (10%). These same four species had become the sub-dominants by Year 15.

#### 9.1.1.2 Claypan Prairie Type: 38% Initial Cover of Woody Species

The overall successional pattern in the claypan prairie simulations was similar to that for the blackland type (Table 9.1). Tree biomass increased over the 25 years, with the entire increase coming from huisache. Huisache biomass doubled in the first 15 years and then increased by another 50% over the following ten years. All other woody species decreased over the 25 years.

As with the blackland type, all herbaceous lifeforms decreased in biomass over the 25 years, although grass-likes increased by Year 15 and then decreased. All individual herbaceous species also decreased in biomass over the 25 years as a result of the increase in huisache.

#### 9.1.1.3 Loamy Prairie Type: 38% Initial Cover of Woody Species

Huisache also increased on this type but at a slower initial rate than on the blackland and claypan prairie types (Table 9.1). Huisache biomass increased by 78% by Year 15 on the loamy prairie site, compared to doubling over the same period on the two previous types. The slower rate of huisache growth was the result of increased competition from grasses. Grass biomass increased by 60% by the end of 15 years whereas it decreased on the blackland and claypan prairie types. The increase in grasses resulted in slower growth of young huisache plants. However, once the huisache reached a mature size, the grasses had little restrictive effect on further growth. By the end of the 25-year simulation, huisache had increased 191% over initial conditions. This compares to an increase of 204% over the same time on the blackland type and 195% on the claypan prairie type. The slower rate of increase (15-year) on the loamy prairie site suggests that a vigorous stand of grasses will slow the invasion rate of huisache but will not stop it. Eventually, the huisache will become of sufficient size to out-compete the grasses.

All other woody species decreased on the loamy prairie type, but generally at a slower rate than on the blackland and claypan prairie types. This slower rate of decline was likely the result of lower competition from huisache. Mesquite had a very minor (2%) decline between 20 and 25 years on the loamy prairie type.

Both midgrasses and shortgrasses increased in biomass on this type over the first 15 years. The midgrasses with the greatest increases were little bluestem (+ 92 $g/m^2$ = 82%), Johnsongrass (+ 26 $g/m^2$ = 289%), and smutgrass (+ 21 $g/m^2$ = 140%). The two shortgrasses with the greatest increases were brownseed paspalum (+ 40 $g/m^2$ = 105%) and knotroot bristlegrass (+ 30 $g/m^2$ = 167%). All species of grass-likes and forbs decreased by Year 15. Compared to initial conditions, total grass aboveground biomass had decreased by 20% after 25 years in response to the increase in huisache. On the loamy prairie type, woody plant cover (trees and shrubs combined) increased from 38% initially to 52% by Year 25. Based on huisache cover data from

Welder Wildlife Refuge (Scrifes et al. 1982), this amount of increase in woody cover would result in a decrease in grass biomass of about 24%, of just slightly more than the 20% decrease in the simulation.

The simulations also produced successional responses by individual species that are consistent with those expected in the region (Fig 9.1). Among the midgrasses, bushy bluestem is an early mid-seral species that decreases as succession proceeds to later stages, which is what occurred in the simulation. Little bluestem is the dominant herbaceous species on this type during mid-seral and the early phase of late-seral stages. In the simulation, little bluestem increased through the first 20 years and then slowly decreased. Under late-seral conditions, tallgrasses such as big bluestem and switchgrass increase and slowly replace little bluestem as dominants. This response occurred in the simulation as both big bluestem and switchgrass increased in 20-25 years, resulting in the slow decrease in little bluestem. Perennial forbs are most abundant on this type during early stages of succession and then begin to decrease as they are replaced by mid- and tallgrasses. Both ragweed and bush sunflower, two common perennial forbs on this type, increased during the first five years and then decreased as little bluestem increased.

#### 9.1.1.4 Sandy Loam Type: 38% Initial Cover of Woody Species

Vegetation dynamics on the sandy loam type exhibited a very different pattern from those on the other three upland types (Table 9.1). Tree biomass, including huisache, decreased over both the 15- and 25-year periods on the sandy loam type, as did the two shrub species. Woody species biomass decreased 7% by Year 15 and 13% by Year 25. This decrease was the result of the increase in herbaceous species, little bluestem in particular. Huisache biomass was low (116 $g/m^2$) initially on this type and did not become competitive with the midgrasses. Little bluestem is well-adapted to sandy and sandy loam soils and was able to effectively utilize the available soil moisture before huisache could increase sufficiently to shade-out the grasses.

The average annual rainfall in the baseline scenario was 36.82 inches (93.5 cm) over the 25-year simulation. This amount of annual rainfall is marginal for support of woodlands. Forty inches of annual rainfall is a general estimate of the level where woodlands dominate over grasslands (Weaver and Clements 1938:510; Engle 1994; Bailey 1995). Stoddart and Smith (1955:48) suggested 38 inches for the transition to tallgrass prairie and Drawe (1994) considered 36 inches to be the transition point on the Coastal Prairies of Texas. At 36.8 inches of rainfall, conditions would be marginal for support of established woodlands and unfavorable for the establishment of woodlands as long as grasses were abundant and productive. In the blackland, claypan prairie, and loamy prairie types, huisache was well-established initially and therefore was able to out-compete the grasses. On the sandy loam type, huisache was not well-established and the marginal rainfall regime was not sufficient to allow it to overcome the competition from grasses.

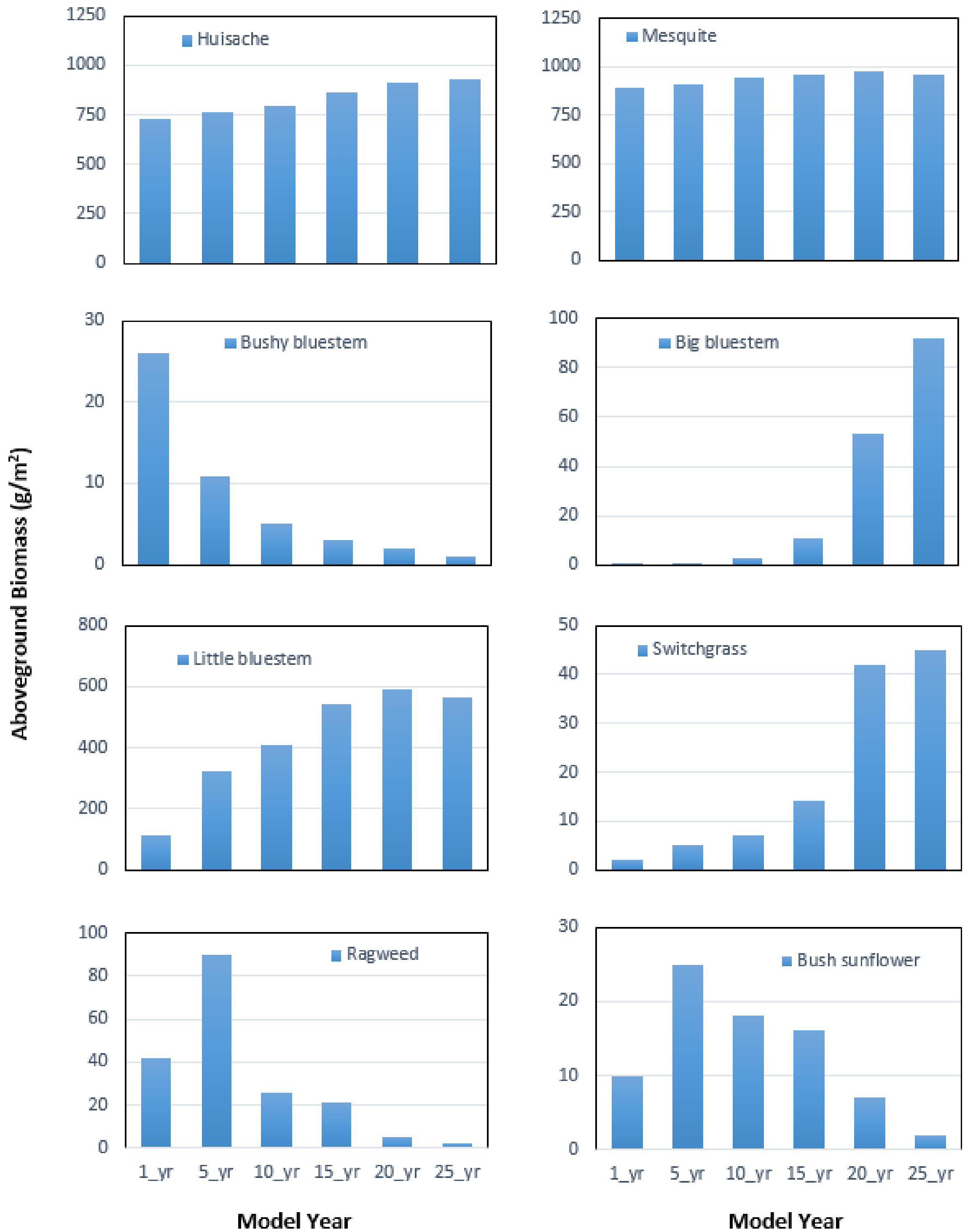


**Figure 9.1 Changes in aboveground biomass of selected successional species on the loamy prairie type over a 25-year simulation under the moderate precipitation regime and without livestock grazing, Victoria County EDYS model. Note that Y-axis scales differ among graphs.**

The substantial increase in grasses on the sandy loam type over the 25 years of the baseline scenario is likely to have been the result of three primary factors. First, is the rainfall regime. Mid- and tallgrass prairie commonly occurs on areas receiving 20-40 inches of rain annually (Weaver and Clements 1938:517; Weaver 1954:7; Shelford 1963:334; Stoddart et al. 1975:28; Smeins and Diamond 1983; Smeins 1994a; Bailey 1995:46). Consequently, the 36-37 inches average annual rainfall level is near the upper level for grasslands and therefore would favor relatively high production by grasses. Second, there was no livestock grazing. Third, competition from huisache was low.

At the end of the 25-year simulation, total aboveground grass production was 698 g/m$^2$ (Table 9.1). This amount includes basal crown biomass, which is seldom included in biomass values reported in literature studies of grassland production. Clippable biomass, which is what most literature studies report, for grasses in EDYS simulations varies by species and conditions, but averages about 60% of total aboveground biomass. Converting the total aboveground biomass value of 698 g/m$^2$ to clippable would equal 419 g/m$^2$ of aboveground biomass in an above-average rainfall year (40 inches). This compares favorably with published values for bluestem grasslands (Table 9.2).

**Table 9.2 Aboveground production (g/m$^2$ clippable biomass) and annual precipitation (PPT; inches) reported for various bluestem and coastal prairie communities.**

| Community | Location | PPT | Production | Reference |
|---|---|---|---|---|
| Big bluestem-little bluestem | Kansas | 34.4 | 357 | Briggs & Knapp 1995 |
| Big bluestem-little bluestem | Kansas | 31.9 | 325 | Owensby & Anderson 1967 |
| Big bluestem-little bluestem | Oklahoma | 44.8 | 349 | Brummer et al. 1988 |
| Little bluestem-big bluestem | Oklahoma | 32.7 | 422 | Hazell 1967 |
| Tall dropseed-silver bluestem | Oklahoma | 32.7 | 355 | Hazell 1967 |
| Sandhill bluestem-splitbeard bluestem | Louisiana | 57.9 | 340 | Duvall & Linnartz 1967 |
| Sandhill bluestem-splitbeard bluestem | Louisiana | 57.9 | 377 | Grelen & Epps 1967 |
| Little bluestem-tall dropseed | Texas (Hood) | 31.5 | 208 | McLendon et al. 2001 |
| Seacoast bluestem-balsamscale | Texas (ANWR) | 34.2 | 542 | McLendon 2014 |
| Buffalogass-silver bluestem | Texas (WWR) | 28.3 | 164 | Box & White 1969 |
| Mean for bluestem communities | | 38.6 | 344 | |
| Knotroot bristlegrass-plains bristlegrass | Texas (WWR) | 28.3 | 249 | Box & White 1969 |
| Gulf cordgrass-bermudagrass | Texas (WWR) | 33.0 | 543 | Garza et al. 1994 |

Hood = Fort Hood; ANWR = Aransas National Wildlife Refuge; WWR = Welder Wildlife Refuge.

Composition of the herbaceous community also changed on the sandy loam type through the 25-year simulation (Table 9.1). The initial plant community was dominated by little bluestem (21%), with substantial amounts of balsamscale (15%), ragweed (13%), arrowfeather threeawn (10%), and brownseed paspalum (6%)(Table 9.3). These five species are commonly the major species on sandy and sandy loam sites in South Texas and the Coastal Prairies (Drawe and Box 1969; McLendon 1977, 1991, 2014; McLendon et al. 2012c, 2012d, 2013b). After 15 years, little bluestem increased in both biomass (325 g/m$^2$) and composition (44%), with ragweed and bush sunflower as subdominants. Total herbaceous biomass had almost tripled. At the end of 25 years, little bluestem produced 67% of the herbaceous biomass. The subdominant species by this time was sideoats grama (11%). The previous subdominant species are mid-seral species on sandy and sandy loam sites in the region and were largely replaced by the late-seral little bluestem and sideoats grama. In Year 25 of the simulation, little bluestem had a biomass of 518 g/m$^2$, or about 409 g/m$^2$ clippable biomass (79%; Appendix Table E.2), and a relative composition of 67%. An ungrazed seacoast bluestem (*Schizachyrium scoparium* var. *littoralis*) prairie on the Aransas National Wildlife Refuge produced 389 g/m$^2$ of seacoast bluestem and had relative composition of 76% (McLendon 2014). Therefore, the simulation results closely match field data for the area.

**Table 9.3 Aboveground biomass (g/m$^2$) and composition (% of total herbaceous biomass) of the major species in the herbaceous community for the sandy loam type, Victoria County EDYS model, at the end of the growing seasons in Years 01, 15, and 25.**

| Species | Biomass | | | Composition | | |
|---|---|---|---|---|---|---|
| | 01 | 15 | 25 | 01 | 15 | 25 |
| Little bluestem | 53 | 325 | 518 | 21.2 | 43.9 | 67.3 |
| Panamerican balsamscale | 37 | 36 | 16 | 14.8 | 4.9 | 2.1 |
| Ragweed | 32 | 184 | 41 | 12.8 | 24.8 | 5.3 |
| Arrowfeather threeawn | 24 | 13 | 7 | 9.6 | 1.8 | 0.9 |
| Brownseed paspalum | 16 | 24 | 20 | 6.4 | 3.2 | 2.6 |
| Plains bristlegrass | 10 | 30 | 28 | 4.0 | 4.0 | 3.6 |
| Bush sunflower | 9 | 81 | 30 | 3.6 | 10.9 | 3.9 |
| Sideoats grama | 2 | 22 | 86 | 0.8 | 3.0 | 11.2 |
| Other species | 67 | 26 | 23 | 26.8 | 3.5 | 3.1 |
| Total herbaceous | 250 | 741 | 769 | 100.0 | 100.0 | 100.0 |

Big bluestem is considered to be a major species under late-seral conditions on the more mesic sandier-textured soils on the Coastal Plains (Drawe et al. 1978; McLendon 1991; Smeins 1994b). Big bluestem increased on the sandy loam type from 1 g/m$^2$ in the first year to 7 g/m$^2$ 25 years later (Table 9.1). Indiangrass, another late-seral tallgrass species, also increased to 7 g/m$^2$ in Year 25. Although the combined biomass of these two tallgrass species was still a minor part of the herbaceous community (1%), their increases during the 25 years of succession suggest a slow shift toward a mixed mid-grass/tallgrass prairie which is compatable with the moderate rainfall regime being at the upper end of the average annual rainfall for grasslands (36-40 inches).

### 9.1.1.5 Loamy Bottomland Type: 38% Initial Cover of Woody Species

On the loamy bottomland type, tree biomass slowly decreased over the 25-year simulation at an average rate of about 0.5% per year (13% overall; Table 9.4). All tree species declined in biomass but the rate of decline was the slowest for the late-seral species pecan and live oak (7% and 10%, respectively) and most rapid for the mid-seral species huisache, hackberry, and mesquite (23% each). The average annual rainfall under this scenario was 36.8 inches and this is marginal, at best, for the support of woodlands in this region. The woodlands exist on the loamy bottomland type because of access to groundwater (Table 8.8). Although groundwater is plentiful on this type, many tree species preferentially utilize rainwater-derived soil moisture rather than groundwater (Section 8.2.1.3), using groundwater more for maintenance than for growth. The slow decline in tree biomass over the 25 years suggests that this rainfall regime (average of 37 inches per year) is inadequate to support these woodlands over longer periods of time (e.g., $100^+$ years) and that they may have been established under a previous, wetter climatic regime (Drawe et al. 1978).

**Table 9.4 Aboveground biomass (g/m$^2$), by lifeform and major species, in the loamy bottomland type (38% initial cover of woody species) at the end of the growing season in the first and each 5-years thereafter of a 25-year simulation under the baseline scenario (average rainfall pattern, no livestock grazing), Victoria County EDYS model.**

| Lifeform/Species | Year 1 | Year 5 | Year 10 | Year 15 | Year 20 | Year 25 | 25-Year Mean |
|---|---|---|---|---|---|---|---|
| Trees | 4369 | 4342 | 4189 | 4054 | 3923 | 3800 | 4111 |
| Shrubs and vines | 744 | 678 | 538 | 453 | 395 | 352 | 516 |
| Midgrasses | 87 | 128 | 84 | 69 | 46 | 34 | 76 |
| Shortgrasses | 68 | 86 | 59 | 46 | 32 | 26 | 53 |
| Grass-likes | 44 | 141 | 177 | 257 | 274 | 211 | 184 |
| Forbs | 42 | 446 | 586 | 566 | 620 | 667 | 517 |
| | | | | | | | |
| Total aboveground | 5354 | 5821 | 5633 | 5445 | 5290 | 5090 | 5457 |
| | | | | | | | |
| Huisache | 253 | 235 | 225 | 214 | 205 | 196 | 219 |
| Pecan | 967 | 986 | 961 | 940 | 917 | 896 | 947 |
| Sugar hackberry | 742 | 724 | 681 | 645 | 610 | 577 | 662 |
| Mesquite | 294 | 277 | 262 | 249 | 237 | 226 | 256 |
| Live oak | 2113 | 2120 | 2060 | 2006 | 1954 | 1905 | 2027 |
| | | | | | | | |
| Macartney rose | 407 | 347 | 262 | 210 | 179 | 157 | 251 |
| Rattlepod | 18 | 11 | 6 | 3 | 2 | 1 | 6 |
| Greenbriar | 18 | 33 | 20 | 16 | 11 | 8 | 19 |
| Mustang grape | 301 | 287 | 250 | 224 | 203 | 186 | 240 |
| | | | | | | | |
| Big bluestem | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Bushy bluestem | 22 | 27 | 21 | 18 | 14 | 10 | 19 |
| Silver bluestem | 5 | 3 | 3 | 3 | 2 | 2 | 3 |
| Sideoats grama | 7 | 11 | 6 | 6 | 5 | 4 | 7 |
| Virginia wildrye | 3 | 2 | 1 | 1 | t | t | 1 |
| Switchgrass | 6 | 7 | 4 | 4 | 3 | 3 | 4 |
| Little bluestem | 13 | 21 | 11 | 8 | 5 | 4 | 10 |
| Plains bristlegrass | 7 | 9 | 5 | 5 | 5 | 4 | 6 |
| Indiangrass | 2 | 3 | 1 | 1 | 1 | 1 | 1 |
| Johnsongrass | 21 | 44 | 31 | 22 | 10 | 5 | 24 |
| | | | | | | | |
| Buffalograss | 10 | 6 | 2 | 1 | 1 | t | 3 |
| Bermudagrass | 8 | 5 | 2 | 1 | t | t | 2 |
| Longtom | 7 | 5 | 4 | 3 | 2 | 2 | 4 |
| Brownseed paspalum | 18 | 47 | 44 | 37 | 27 | 23 | 36 |
| Knotroot bristlegrass | 22 | 21 | 6 | 4 | 2 | 1 | 7 |
| Texas wintergrass | 3 | 2 | 1 | t | t | t | 1 |
| | | | | | | | |
| Littletooth sedge | 23 | 67 | 122 | 195 | 202 | 142 | 129 |
| Flatsedge | 21 | 74 | 55 | 62 | 72 | 69 | 55 |
| | | | | | | | |
| Spiny aster | 4 | 10 | 8 | 6 | 5 | 3 | 7 |
| Ragweed | 25 | 393 | 488 | 366 | 293 | 300 | 337 |
| Wild indigo | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| Old-man's beard | 8 | 40 | 89 | 193 | 321 | 363 | 172 |
| Frogfruit | 2 | 1 | t | t | t | t | t |
| Snoutbean | 1 | 1 | t | t | t | t | t |

Trace amounts (< 0.5 g/m$^2$) are indicated with a "t".

Drawe ete al. (1978) reported that live oak communities on the Welder Wildlife Refuge typically consist of older trees with little evidence of regeneration of the stand. Lack of young trees could be the result of insufficient soil moisture available to seedlings and saplings because of sub-optimum rainfall and intense competition for the soil moisture from herbaceous species. Dense stands of ragweed, both perennial ragweed and giant ragweed (bloodweed), are common along bottomlands and drainages in South Texas and the Coastal Prairies. In the simulation, ragweed biomass increased rapidly by the fifth year (400 $g/m^2$; Table 9.4) and remained high (300-450 $g/m^2$) for the remainder of the 25 years. These amounts of ragweed biomass are not unusual along these bottomland types. Validation plots were established on the edge of a bottomland community along the San Antonio River in Goliad County. In 2014, ragweed was not recorded as occurring in these plots (McLendon 2015). The following year, ragweed averaged 562 $g/m^2$ clippable biomass in the same plots.

Shrubs and vines also decreased over the 25-year simulation (Table 9.4). The major shrub was Macartney rose, an aggressive species that forms dense thickets. However, the initial biomass of this shrub was relatively low in the simulation (407 $g/m^2$ = 7% canopy cover; Appendix Table C.23) and this species is better adapted to higher rainfall areas or areas with frequent standing water. Although groundwater was available to Macartney rose in most areas of this type (average DTW = 8.8 feet, Table 8.8; maximum rooting depth for Macartney rose = 12 feet, Appendix Table E.9), it was located in the lower portion of the potential rooting zone. Groundwater use by plants decreases as depth to groundwater increases. For example, ET rates of mesquite growing in an Arizona floodplain where DTW was 10 m (32.8 feet) was 60% of ET when DTW was 3.5 m (11.5 feet)(Scott et al. 2006). The locations were adjacent to each other, therefore the difference in ET was largely the result of differences in groundwater use. The decrease in Macartney rose biomass over time in the 25-year simulation was likely the result of the interaction of these three factors (i.e., small initial stands of the shrub, marginal soil moisture, and limited groundwater use) with very strong competition for soil moisture from dense stands of ragweed and old-man's beard.

Grass biomass increased over the first five years and then declined thereafter (Table 9.4). The initial increases were a result of relatively low forb biomass in the first few years. Two midgrasses, little bluestem and Johnsongrass, and one shortgrass, brownseed paspalum, increased substantially during the first five years of the simulation. The annual reinfall used in the moderate regime for the first five years (1962-66) was relatively low, averaging only 29.3 inches. At this lower level of rainfall, ragweed and old-man's beard took several years to increase in biomass sufficiently to become serious competitors to the grasses. However once annual rainfall increased and the forbs were able to maintain high productivity, grass production was negatively affected. Initial grass biomass was low (155 $g/m^2$) and this allowed the more rapidly growing forbs to increase. Had grass biomass been substantially higher initially, it is unlikely that there would have been such a rapid increase of forbs.

The sedges were more competitive relative to forbs than were grasses. Littletooth sedge (*Carex microdonta*) increased through Year 20 and then began to decline and flatsedge increased rapidly in the first five years and then remained relatively stable for the remainder of the simulation (Table 9.4). Both species are favored by the more mesic conditions of the bottomland type.

In addition to ragweed, old-man's beard slowly became a dominant forb on this type, even surpassing ragweed in biomass by Year 20 (Table 9.4). Old-man's beard is an herbaceous vine best adapted to mesic sites where it can form dense stands that over-grow other species, including short trees such as huisache (Drawe et al. 1978), and forming near monoculture stands (McLendon 1991).

#### 9.1.1.6 Salty Bottomland Type: 38% Initial Cover of Woody Species

This is an example of the gulf cordgrass flats that occur on saline floodplains near the coast (Drawe et al. 1978; Scifres et al. 1980; Drawe 1994; Garza et al. 1994). In its purest form, the community consists of an almost monoculture of gulf cordgrass, with a few scattered woody plants and small amounts of other herbaceous species. Canopy cover of gulf cordgrass can approach 100% on some sites. Many examples of this type now have a discontinuous cover of gulf cordgrass and support substantial amounts of woody species, especially huisache and mesquite (Drawe 1994; McLendon et al. 2013b). Major factors contributing to the decline in gulf cordgrass on these sites are overgrazing by livestock and reduction in surface water supply.

Vegetation dynamics in the simulation of this type were dominated by 1) the rapid increase in huisache in the first five years and 2) the increase in gulf cordgrass over the first 10 years (Table 9.5). Huisache tripled in biomass between Years 1 and 5. This was because of rapid growth of established huisache plants and little competition from other species, therefore abundant resources were available to sustain the huisache growth. The major competitor on this site is gulf cordgrass. Full production of gulf cordgrass is 600-700 $g/m^2$ total aboveground biomass (e.g., Year 10, Table 9.5). At the end of the first growing season, gulf cordgrass biomass was 187 $g/m^2$, or less than 30% of its potential. Huisache was more abundant initially and took advantage of the under-utilized resources. After Year 5, huisache biomass remained stable as gulf cordgrass increased.

Mesquite is the other tree species that is a major invader in the gulf cordgrass communities (Drawe 1994; McLendon et al. 2012c, 2013b). Mesquite biomass increased in the simulations by about 40% after 20 years (Table 9.5). Mesquite is a slower-growing and later successional species than huisache, and less adapted to wet conditions than huisache. Therefore it is reasonable that it increased at a slower rate and remained less productive than huisache.

Sea oxeye was the most abundant shrub on this site. It is best adapted to open mud flats and sand or shell bars, where it can form dense stands. Sea oxeye declined in biomass during the 25 years of succession (Table 9.5) in response to competition and shading from gulf cordgrass. Sea oxeye is seldom found in abundant amounts in dense stands of *Spartina* and other marsh species and this was the response in the simulation.

Gulf cordgrass is the dominant species on these sites. The simulation began with relatively low levels of gulf cordgrass and the species increased under the moderate rainfall regime and in the absence of livestock grazing. By Year 10, total aboveground biomass reached 695 $g/m^2$ and then stabilized at about 585 $g/m^2$ (Table 9.5), which are equivalent to about 610 and 515 $g/m^2$

**Table 9.5 Aboveground biomass (g/m$^2$), by lifeform and major species, in the salty bottomland type (38% initial cover of woody species) at the end of the growing season in the first and each 5-years thereafter of a 25-year simulation under the baseline scenario (average rainfall pattern, no livestock grazing), Victoria County EDYS model.**

| Lifeform/Species | Year 1 | Year 5 | Year 10 | Year 15 | Year 20 | Year 25 | 25-Year Mean |
|---|---|---|---|---|---|---|---|
| Trees | 2001 | 5216 | 5383 | 5377 | 5363 | 5306 | 5093 |
| Shrubs | 177 | 144 | 123 | 107 | 98 | 88 | 119 |
| Midgrasses | 188 | 436 | 696 | 628 | 586 | 585 | 533 |
| Shortgrasses | 43 | 35 | 42 | 37 | 42 | 22 | 36 |
| Grass-likes | 19 | 13 | 39 | 73 | 94 | 74 | 50 |
| Forbs | 27 | 21 | 58 | 140 | 201 | 205 | 108 |
| Total aboveground | 2455 | 5865 | 6341 | 6362 | 6384 | 6280 | 5939 |
| Huisache | 1672 | 4849 | 4955 | 4930 | 4901 | 4847 | 4671 |
| Mesquite | 329 | 367 | 428 | 447 | 462 | 459 | 422 |
| Sea oxeye | 129 | 117 | 108 | 99 | 93 | 85 | 104 |
| Rattlepod | 48 | 27 | 15 | 8 | 5 | 3 | 15 |
| Little bluestem | 1 | 1 | 1 | 1 | t | t | 1 |
| Gulf cordgrass | 187 | 435 | 695 | 627 | 586 | 585 | 532 |
| Buffalograss | 2 | 1 | 1 | t | t | t | 1 |
| Bermudagrass | 9 | 4 | 3 | 2 | 2 | 1 | 3 |
| Saltgrass | 32 | 30 | 38 | 35 | 40 | 21 | 32 |
| Olney bulrush | 19 | 13 | 39 | 73 | 94 | 74 | 50 |
| Spiny aster | 5 | 8 | 28 | 96 | 148 | 182 | 78 |
| Glasswort | 21 | 13 | 30 | 44 | 53 | 23 | 30 |

A trace amount (< 0.5 g/m$^2$) is indicated with a "t".

clippable biomass, respectively. This compares to 543 g/m$^2$ for gulf cordgrass in a similar community on the Welder Wildlife Refuge (Garza et al. 1994), with an average annual rainfall of 33.0 inches for the study years. The annual annual rainfall over the period of the simulation was higher, 36.8 inches, so the simulation value of 585 g/m$^2$ clippable biomass is very reasonable.

Two other species increased substantially during the simulation (Table 9.5). Olney bulrush (*Scirpus americanus*) is a common species in the wetter portions of the gulf cordgrass community, especially as it transitions to tidal marsh communities. This species increased between Years 5 and 20, which was a wet period (average annual mean = 41.6 inches) during the moderate rainfall regime. The higher rainfall and increased runoff onto the type allowed bulrush to increase in biomass. Spiny aster (*Aster spinosus*) is a coarse perennial that often forms dense, almost monoculture stands on wet sites along the central Texas Coast (Drawe 1994). It also increased in the simulation during the wet period but was slower to begin increasing than bulrush because of its lower initial biomass. Unlike bulrush, spiny aster continued to increase throughout the simulation, suggesting that this site might eventually develop into a spiny aster community under wet conditions. However, spiny aster is better adapted to freshwater rather than saline wetlands. Should the site remain saline, gulf cordgrass is likely to remain the dominant species.

### 9.1.2 Effect of Rainfall Regimes

The moderate rainfall regime was simulated using rainfall data from 1962-1985, during which annual rainfall averaged 36.82 inches. Two other regimes were also simulated. The dry regime utilized rainfall data from 1932-1956, which had an annual average of 32.10 inches (0.87 of moderate), and the wet regime utilized rainfall data from 1983-2007, which had an annual average of 42.34 inches (1.15 of moderate). The dry regime contained three years with high rainfall (1936 = 46.7 inches; 1941 = 51.0 inches, 1944 = 43.5 inches) and the wet regime contained four dry years (1988 = 15.9 inches; 1989 = 27.0 inches; 1996 = 28.7 inches; 1999 = 27.0 inches). All factors except rainfall remained the same as for the moderate regime (e.g., same initial biomass and species composition values, no livestock grazing).

#### 9.1.2.1 Dry Regime Vegetation Response

Overall mean aboveground biomass, averaged over the six plot types and over the 25 years of the simulation, was 4,641 g/m$^2$, of which 4,174 g/m$^2$ (90%) were from woody species and 467 g/m$^2$ (10%) were from herbaceous species. Under the baseline scenario (moderate rainfall regime), these values were 4,733 g/m$^2$ total, 4,246 g/m$^2$ woody, and 487 g/m$^2$ herbaceous. Rainfall for the dry scenario was 12.8% less than under the baseline scenario. The reduction in rainfall resulted in total aboveground biomass decreasing by 2.0%. However, the effect of the reduced rainfall was not uniform over lifeforms. Herbaceous species biomass decreased by 4.0% whereas woody species decreased by 1.7%. The fact that biomass decreased less than did rainfall is the result of increased use of groundwater under the dry regime. The lower reduction in biomass of woody species compared to herbaceous species was the result of the greater rooting depth of woody species compared to herbaceous species, with the corresponding ability of woody species to utilize more groundwater.

Response to the dry regime also varied by vegetation type, species within lifeforms, and species among vegetation types. On the blackland type, all woody species decreased under the dry regime compared to the moderate regime (Table 9.6). Biomass of woody species decreased by an average of 9%, but the greatest decrease was by huisache (13%) and the least was by live oak (1%). Of the tree species included in this type, huisache had the shallowest root system (Appendix Table E.9) and therefore had the least access to groundwater. Both shortgrasses and grass-likes increased on this type under the dry regime because of less competition from woody species, midgrasses, and forbs. The primary shortgrass that increased under the dry regime was knotroot bristlegrass. All midgrasses except plains bristlegrass either decreased or remained stable under the dry regime. Plains bristlegrass is adapted to drier conditions than most of the other midgrasses and therefore was able to increase because of less competition from the other species.

Woody species overall decreased by 3% on the claypan prairie type, compared to the moderate regime (Table 9.6). On this type, huisache decreased by 5% but mesquite did not decrease and live oak increased by 2%. Groundwater is deeper on this type than on the blackland type (2-75 feet and 3-40 feet, respectively; Table 8.8) and this shifted more competitive advantage to the deeper-rooted trees. Both midgrasses and shortgrasses also increased in biomass under the dry regime because of reduced competition from huisache. Smutgrass was the primary midgrass that

**Table 9.6 Aboveground biomass (g/m$^2$), by lifeform and major species, in blackland and claypan prairie plot types at the end of the growing season in Year 25 and overall annual mean of a 25-year simulation under dry, moderate (Mod), and wet precipitation scenarios, Victoria County EDYS model. Average annual rainfall for the dry scenario = 32.10 inches, for the moderate scenario = 36.82 inches, and for the wet scenario = 42.34 inches.**

| Lifeform or Species | Blackland (38% initial woody cover) Year 25 | | | Blackland 25-Year Mean | | | Claypan Prairie (38% initial woody cover) Year 25 | | | Claypan Prairie 25-Year Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry | Mod | Wet | Dry | Mod | Wet | Dry | Mod | Wet | Dry | Mod | Wet |
| Trees | 2910 | 3549 | 3491 | 2262 | 2519 | 2307 | 2923 | 3189 | 4058 | 2408 | 2456 | 2674 |
| Shrubs | 480 | 544 | 492 | 726 | 774 | 725 | 833 | 931 | 889 | 1206 | 1260 | 1214 |
| Midgrasses | 36 | 47 | 193 | 79 | 95 | 129 | 28 | 19 | 49 | 66 | 48 | 73 |
| Shortgrasses | 29 | 17 | 87 | 90 | 64 | 100 | 16 | 16 | 19 | 46 | 41 | 41 |
| Grass-Likes | 7 | 3 | 50 | 27 | 14 | 33 | 2 | 8 | 6 | 19 | 27 | 18 |
| Forbs | 10 | 20 | 25 | 32 | 42 | 35 | 4 | 4 | 6 | 19 | 17 | 19 |
| Total aboveground | 3472 | 4180 | 4338 | 3216 | 3508 | 3329 | 3806 | 4167 | 5027 | 3764 | 3849 | 4039 |
| Huisache | 2116 | 2700 | 2750 | 1476 | 1703 | 1547 | 1879 | 2157 | 2999 | 1290 | 1354 | 1557 |
| Sugar hackberry | 78 | 79 | 78 | 89 | 90 | 89 | --- | --- | --- | --- | --- | --- |
| Mesquite | 625 | 678 | 572 | 601 | 629 | 575 | 113 | 113 | 113 | 128 | 128 | 127 |
| Live oak | 91 | 92 | 91 | 96 | 97 | 96 | 931 | 919 | 946 | 990 | 974 | 990 |
| Baccharis | 50 | 67 | 65 | 91 | 102 | 91 | 86 | 108 | 113 | 138 | 148 | 138 |
| Macartney rose | 419 | 458 | 412 | 609 | 637 | 612 | 744 | 820 | 773 | 1053 | 1097 | 1061 |
| Greenbriar | 11 | 19 | 15 | 26 | 35 | 22 | --- | --- | --- | --- | --- | --- |
| Rattlepod | --- | --- | --- | --- | --- | --- | 3 | 3 | 3 | 15 | 15 | 15 |
| Big bluestem | 1 | 1 | 1 | 1 | 1 | 1 | t | t | t | t | t | 1 |
| Bushy bluestem | 1 | 1 | 2 | 6 | 7 | 6 | 1 | 1 | 2 | 5 | 6 | 6 |
| Silver bluestem | 5 | 6 | 5 | 7 | 8 | 6 | --- | --- | --- | --- | --- | --- |
| Sideoats grama | 1 | 2 | 3 | 3 | 3 | 3 | --- | --- | --- | --- | --- | --- |
| Virginia wildrye | t | t | t | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Switchgrass | 1 | 1 | 1 | 2 | 2 | 2 | t | t | 1 | 1 | 1 | 1 |
| Little bluestem | 13 | 15 | 10 | 29 | 33 | 22 | 12 | 11 | 12 | 28 | 27 | 27 |
| Plains bristlegrass | 2 | 1 | 5 | 5 | 2 | 4 | --- | --- | --- | --- | --- | --- |
| Indiangrass | 1 | 1 | 1 | 1 | 1 | 1 | t | t | 1 | 1 | 1 | 1 |
| Johnsongrass | 1 | 2 | 3 | 6 | 8 | 5 | --- | --- | --- | --- | --- | --- |
| Tall dropseed | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 |
| Smutgrass | 9 | 16 | 161 | 17 | 28 | 76 | 14 | 6 | 32 | 29 | 12 | 35 |
| Purple threeawn | 3 | 3 | 3 | 7 | 7 | 6 | --- | --- | --- | --- | --- | --- |
| Buffalograss | 1 | 1 | 1 | 14 | 14 | 11 | --- | --- | --- | --- | --- | --- |
| Hooded windmillgrass | --- | --- | --- | --- | --- | --- | t | t | t | 1 | 1 | 1 |
| Bermudagrass | t | t | t | 3 | 3 | 3 | t | t | t | 3 | 3 | 3 |
| Longtom | 2 | 2 | 2 | 5 | 5 | 5 | 3 | 3 | 3 | 7 | 7 | 7 |
| Brownseed paspalum | 11 | 9 | 22 | 25 | 22 | 21 | 2 | 2 | 2 | 5 | 4 | 4 |
| Thin paspalum | 1 | 1 | 1 | 5 | 5 | 5 | t | t | 1 | 2 | 2 | 2 |
| Knotroot bristlegrass | 9 | 1 | 41 | 22 | 7 | 32 | 11 | 11 | 13 | 28 | 24 | 24 |
| Texas wintergrass | 2 | t | 17 | 9 | 1 | 17 | --- | --- | --- | --- | --- | --- |
| Littletooth sedge | --- | --- | --- | --- | --- | --- | 1 | 7 | 3 | 10 | 18 | 9 |
| Flatsedge | 7 | 3 | 50 | 27 | 14 | 33 | 1 | 1 | 3 | 9 | 9 | 9 |
| Ragweed | t | t | t | 9 | 11 | 9 | t | t | 1 | 8 | 7 | 8 |
| Wild indigo | 3 | 3 | 4 | 6 | 6 | 6 | 4 | 4 | 5 | 9 | 9 | 9 |
| Old-mans beard | 7 | 16 | 20 | 9 | 15 | 12 | --- | --- | --- | --- | --- | --- |
| Bundleflower | t | t | t | t | t | t | 0 | 0 | t | 1 | t | 1 |
| Frogfruit | t | t | t | 2 | 2 | 2 | t | t | t | 1 | 1 | 1 |
| Ruellia | t | t | t | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Bush sunflower | t | 1 | 1 | 5 | 7 | 5 | --- | --- | --- | --- | --- | --- |

increased and knotroot bristlegrass was the primary shortgrass that increased. Smutgrass is an aggressive mid-seral species that commonly increases on the Coastal Plains following disturbance.

The loamy prairie and sandy loam types have coarser soil textures and relatively deep depth to groundwater (average of 33.7 and 22.4 feet, respectively; Table 8.8), therefore vegetation on these two types are more dependent on rainfall than on types with shallower water tables. However, the coarser soil textures allow more of the moisture that is held in the soil to be available to plants. Consequently, there were slight increases in biomass for most woody species under the dry regime on the loamy prairie type and for mesquite and live oak on the sandy loam type (Table 9.7). These increases in biomass of woody species was the result of decreased biomass of herbaceous species under the dry regime. The decrease in herbaceous biomass resulted in more soil moisture becoming available to the woody species, which generally have less biomass of fine roots, and hence less absorption potential, in the upper soil layers than do the herbaceous species. Two exceptions to the overall reduction in herbaceous biomass on the sandy loam type were plains bristlegrass, a more xeric midgrass than most midgrasses on this type, and brownseed paspalum. Brownseed paspalum is commonly a subdominant species to little bluestem on these sandy sites and increased somewhat under the dry regime as little bluestem became less competitive.

The dry regime had only a minor effect on total aboveground biomass on the loamy bottomland type, decreasing by 2% compared to the moderate regime (Table 9.8). Tree biomass was largely unaffected overall (1% decrease) and for each species. This was the result of abundant groundwater available to the trees (average depth less than 9 feet; Table 8.8). Shrubs were affected somewhat more (4% decline) because of shallower rooting zones for the shrubs compared to the trees. Both midgrasses and shortgrasses had higher biomass under the dry regime because of less competition from woody species and especially from other herbaceous species (grass-likes and forbs). Of the midgrasses, plains bristlegrass and Johnsongrass increased the most and bushy bluestem, a wet-site species, had the largest decrease under the dry regime. Two shortgrasses, knotroot bristlegrass and Texas wintergrass (*Stipa leucotricha*), increased substantially under the dry regime, responding favorably to reduced competition from other herbaceous species, in particular littletooth sedge and old-man's beard. Littletooth sedge and old-man's beard are both best adapted to more mesic conditions and their reductions under the dry regime allowed the more xeric shortgrasses to increase.

The salty bottomland site was dominated by huisache and gulf cordgrass under the moderate regime and these two species remained dominant under the dry regime (Table 9.8). Huisache biomass was largely unaffected by the dry regime but gulf cordgrass biomass increased by 21% (112 $g/m^2$) because of a major reduction (54 $g/m^2$ = 69%) in spiny aster biomass. Spiny aster is adapted to more mesic conditions and as the rainfall regime decreased competitive advantage shifted to gulf cordgrass.

**Table 9.7 Aboveground biomass ($g/m^2$), by lifeform and major species, in loamy prairie and sandy loam plot types at the end of the growing season in Year 25 and overall annual mean of a 25-year simulation under dry, moderate (Mod), and wet precipitation scenarios, Victoria County EDYS model. Average annual rainfall for the dry scenario = 32.10 inches, for the moderate scenario = 36.82 inches, and for the wet scenario = 42.34 inches.**

| Lifeform or Species | Loamy Prairie (38% initial woody cover) | | | | | | Sandy Loam (38% initial woody cover) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 25 | | | 25-Year Mean | | | Year 25 | | | 25-Year Mean | | |
| | Dry | Mod | Wet | Dry | Mod | Wet | Dry | Mod | Wet | Dry | Mod | Wet |
| Trees | 3924 | 4118 | 5011 | 3392 | 3363 | 3615 | 4282 | 4223 | 4242 | 4591 | 4526 | 4554 |
| Shrubs | 343 | 340 | 344 | 500 | 497 | 505 | 177 | 177 | 172 | 236 | 243 | 242 |
| Midgrasses | 82 | 139 | 194 | 185 | 235 | 221 | 401 | 668 | 937 | 364 | 382 | 491 |
| Shortgrasses | 42 | 69 | 80 | 87 | 117 | 84 | 28 | 30 | 53 | 58 | 50 | 76 |
| Grass-Likes | t | t | t | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Forbs | 4 | 4 | 6 | 27 | 26 | 27 | 19 | 71 | 20 | 122 | 207 | 98 |
| Total aboveground | 4395 | 4670 | 5635 | 4192 | 4239 | 4453 | 4907 | 5169 | 5424 | 5371 | 5408 | 5461 |
| Huisache | 1926 | 2121 | 2963 | 1281 | 1270 | 1501 | 100 | 99 | 98 | 108 | 109 | 108 |
| Sugar hackberry | 199 | 201 | 199 | 225 | 226 | 224 | 188 | 187 | 187 | 217 | 217 | 217 |
| Mesquite | 872 | 866 | 899 | 900 | 886 | 899 | 805 | 802 | 802 | 913 | 909 | 910 |
| Post oak | --- | --- | --- | --- | --- | --- | 190 | 190 | 190 | 219 | 219 | 219 |
| Live oak | 927 | 930 | 950 | 986 | 981 | 991 | 2999 | 2945 | 2965 | 3134 | 3072 | 3100 |
| Blackbrush | --- | --- | --- | --- | --- | --- | 38 | 40 | 40 | 60 | 65 | 64 |
| Granjeno | --- | --- | --- | --- | --- | --- | 139 | 137 | 132 | 176 | 178 | 178 |
| Macartney rose | 343 | 340 | 344 | 500 | 497 | 505 | --- | --- | --- | --- | --- | --- |
| Big bluestem | 1 | 2 | 2 | 1 | 2 | 2 | 6 | 7 | 29 | 3 | 2 | 9 |
| Bushy bluestem | 1 | 2 | 2 | 7 | 8 | 8 | --- | --- | --- | --- | --- | --- |
| Silver bluestem | --- | --- | --- | --- | --- | --- | 5 | 4 | 5 | 8 | 7 | 8 |
| Sideoats grama | --- | --- | --- | --- | --- | --- | 40 | 86 | 273 | 24 | 28 | 53 |
| Panamerican balsamscale | - | --- | --- | --- | --- | --- | 8 | 16 | 13 | 26 | 39 | 27 |
| Plains lovegrass | t | t | t | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| Switchgrass | 1 | 1 | 1 | 2 | 2 | 2 | --- | --- | --- | --- | --- | --- |
| Little bluestem | 61 | 94 | 60 | 131 | 164 | 121 | 315 | 518 | 548 | 267 | 274 | 345 |
| Plains bristlegrass | --- | --- | --- | --- | --- | --- | 22 | 28 | 55 | 29 | 23 | 40 |
| Indiangrass | 1 | 1 | 1 | 2 | 1 | 2 | 3 | 7 | 11 | 4 | 6 | 6 |
| Johnsongrass | 5 | 15 | 25 | 21 | 29 | 28 | --- | --- | --- | --- | --- | --- |
| Tall dropseed | --- | --- | --- | --- | --- | --- | 1 | 1 | 1 | 1 | 1 | 1 |
| Smutgrass | 12 | 24 | 103 | 20 | 28 | 57 | --- | --- | --- | --- | --- | --- |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 5 | 7 | 6 | 14 | 17 | 14 |
| Purple threeawn | 1 | 1 | 1 | 2 | 2 | 2 | --- | --- | --- | --- | --- | --- |
| Buffalograss | --- | --- | --- | --- | --- | --- | t | t | t | 2 | 2 | 2 |
| Sandbur | --- | --- | --- | --- | --- | --- | 2 | 2 | 1 | 3 | 3 | 3 |
| Bermudagrass | t | t | t | 1 | 1 | 1 | t | 1 | t | 5 | 5 | 5 |
| Longtom | 3 | 3 | 3 | 8 | 8 | 7 | --- | --- | --- | --- | --- | --- |
| Brownseed paspalum | 28 | 37 | 51 | 55 | 64 | 50 | 21 | 20 | 45 | 28 | 18 | 44 |
| Thin paspalum | 1 | 1 | 1 | 3 | 3 | 3 | t | t | t | 2 | 2 | 2 |
| Knotroot bristlegrass | 9 | 27 | 24 | 17 | 38 | 20 | t | t | 1 | 2 | 2 | 4 |
| Texas wintergrass | t | t | t | 1 | 1 | 1 | t | t | t | 2 | 1 | 2 |
| Littletooth sedge | t | t | t | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Ragweed | t | t | 1 | 15 | 14 | 15 | 14 | 41 | 17 | 99 | 153 | 83 |
| Wild indigo | 3 | 3 | 4 | 6 | 6 | 6 | --- | --- | --- | --- | --- | --- |
| Bundleflower | t | t | t | 1 | 1 | 1 | t | t | t | t | t | t |
| Snoutbean | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | t | t | t |
| Bush sunflower | t | t | t | 4 | 4 | 4 | 5 | 30 | 3 | 22 | 54 | 15 |
| Annual broomweed | --- | --- | --- | --- | --- | --- | 0 | 0 | 0 | 1 | t | t |

**Table 9.8 Aboveground biomass ($g/m^2$), by lifeform and major species, in loamy bottomland and salty bottomland types at the end of the growing season in Year 25 and overall annual mean of a 25-year simulation under dry, moderate (Mod), and wet precipitation scenarios, Victoria County EDYS model. Average annual rainfall for the dry scenario = 32.10 inches, for the moderate scenario = 36.82 inches, and for the wet scenario = 42.34 inches. Initial woody cover = 38%.**

| Lifeform or Species | Loamy Bottomland Year 25 Dry | Mod | Wet | Loamy Bottomland 25-Year Mean Dry | Mod | Wet | Salty Bottomland Year 25 Dry | Mod | Wet | Salty Bottomland 25-Year Mean Dry | Mod | Wet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trees | 3758 | 3800 | 3809 | 4073 | 4110 | 4113 | 5415 | 5306 | 5401 | 5032 | 5093 | 5063 |
| Shrubs and vines | 341 | 352 | 353 | 497 | 516 | 518 | 88 | 88 | 95 | 118 | 119 | 118 |
| Midgrasses | 33 | 34 | 52 | 80 | 76 | 91 | 706 | 585 | 756 | 645 | 533 | 608 |
| Shortgrasses | 232 | 26 | 89 | 219 | 53 | 149 | 16 | 22 | 17 | 32 | 36 | 37 |
| Grass-likes | 74 | 211 | 286 | 92 | 184 | 159 | 57 | 74 | 261 | 49 | 50 | 95 |
| Forbs | 498 | 667 | 548 | 417 | 517 | 437 | 54 | 205 | 51 | 49 | 108 | 32 |
| Total aboveground | 4936 | 5090 | 5137 | 5378 | 5456 | 5467 | 6336 | 6280 | 6581 | 5925 | 5939 | 5953 |
| Huisache | 201 | 196 | 198 | 222 | 219 | 222 | 4946 | 4847 | 4963 | 4637 | 4671 | 4625 |
| Pecan | 886 | 896 | 899 | 941 | 946 | 950 | --- | --- | --- | --- | --- | --- |
| Sugar hackberry | 567 | 577 | 575 | 654 | 662 | 660 | --- | --- | --- | --- | --- | --- |
| Mesquite | 224 | 226 | 226 | 255 | 256 | 256 | 469 | 459 | 438 | 395 | 422 | 438 |
| Live oak | 1880 | 1905 | 1911 | 2001 | 2027 | 2025 | --- | --- | --- | --- | --- | --- |
| Sea oxeye | --- | --- | --- | --- | --- | --- | 85 | 85 | 92 | 103 | 104 | 103 |
| Macartney rose | 153 | 157 | 158 | 242 | 251 | 254 | --- | --- | --- | --- | --- | --- |
| Rattlepod | 1 | 1 | 1 | 6 | 6 | 6 | 3 | 3 | 3 | 15 | 15 | 15 |
| Greenbriar | 3 | 8 | 7 | 14 | 19 | 17 | --- | --- | --- | --- | --- | --- |
| Mustang grape | 183 | 186 | 187 | 235 | 240 | 241 | --- | --- | --- | --- | --- | --- |
| Big bluestem | 1 | 1 | 1 | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Bushy bluestem | 2 | 10 | 4 | 10 | 19 | 11 | --- | --- | --- | --- | --- | --- |
| Silver bluestem | 2 | 2 | 2 | 3 | 3 | 3 | --- | --- | --- | --- | --- | --- |
| Sideoats grama | 3 | 4 | 5 | 6 | 7 | 6 | --- | --- | --- | --- | --- | --- |
| Virginia wildrye | t | t | t | 2 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Switchgrass | 3 | 3 | 3 | 4 | 4 | 5 | --- | --- | --- | --- | --- | --- |
| Little bluestem | 5 | 4 | 5 | 11 | 10 | 11 | t | t | t | 1 | 1 | 1 |
| Plains bristlegrass | 10 | 4 | 18 | 14 | 6 | 18 | --- | --- | --- | --- | --- | --- |
| Indiangrass | 1 | 1 | 1 | 2 | 1 | 2 | --- | --- | --- | --- | --- | --- |
| Johnsongrass | 6 | 5 | 13 | 27 | 24 | 33 | --- | --- | --- | --- | --- | --- |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | 706 | 585 | 756 | 644 | 532 | 607 |
| Buffalograss | t | t | t | 3 | 3 | 3 | t | t | t | 1 | 1 | 1 |
| Bermudagrass | t | t | t | 2 | 2 | 2 | t | 1 | t | 3 | 3 | 3 |
| Saltgrass | --- | --- | --- | --- | --- | --- | 16 | 21 | 17 | 28 | 32 | 33 |
| Longtom | 2 | 2 | 2 | 4 | 4 | 4 | --- | --- | --- | --- | --- | --- |
| Brownseed paspalum | 28 | 23 | 27 | 41 | 36 | 34 | --- | --- | --- | --- | --- | --- |
| Knotroot bristlegrass | 152 | 1 | 59 | 137 | 7 | 103 | --- | --- | --- | --- | --- | --- |
| Texas wintergrass | 50 | t | 1 | 32 | 1 | 3 | --- | --- | --- | --- | --- | --- |
| Littletooth sedge | t | 142 | 2 | 13 | 129 | 25 | --- | --- | --- | --- | --- | --- |
| Flatsedge | 74 | 69 | 284 | 79 | 55 | 134 | --- | --- | --- | --- | --- | --- |
| Olney bulrush | --- | --- | --- | --- | --- | --- | 57 | 74 | 261 | 49 | 50 | 95 |
| Spiny aster | 4 | 3 | 1 | 10 | 7 | 3 | 35 | 182 | 3 | 24 | 78 | 5 |
| Ragweed | 473 | 300 | 251 | 379 | 337 | 328 | --- | --- | --- | --- | --- | --- |
| Wild indigo | 1 | 1 | 1 | 1 | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Old-man's beard | 20 | 363 | 295 | 26 | 172 | 105 | --- | --- | --- | --- | --- | --- |
| Snoutbean | t | t | 0 | 1 | t | t | --- | --- | --- | --- | --- | --- |
| Glasswort | --- | --- | --- | --- | --- | --- | 21 | 23 | 48 | 25 | 30 | 27 |

#### 9.1.2.2 Wet Regime Vegetation Response

Overall, total aboveground biomass increased only slightly (1%) under the wet regime compared to the moderate regime. Mean total aboveground biomass, averaged over the six types and over the 25 years of the simulation, was 4,784 g/m$^2$ under the wet regime, of which 88% was from woody species and 12% from herbaceous species. Although total biomass did not increase substantially under the wet regime, herbaceous biomass increased by 11%.

Huisache was the species with highest biomass in four of six types (Tables 9.6-9.8). Under the wet regime, it increased on two types, claypan prairie (+15%) and loamy prairie (+18%), and decreased on two, blackland (- 9%) and salty bottomland (- 1%) when averaged over the 25 years. In the two types where huisache increased, there was either a very moderate increase (claypan prairie) or a decrease (loamy prairie) in herbaceous biomass, indicating that on these two types huisache was very competitive under the higher rainfall regime. Huisache was not as competitive on the blackland type and this lower competitive success was exploited by herbaceous species under the wet regime, particularly smutgrass, Texas wintergrass, and flatsedge, which combined increased by an average of 83 g/m$^2$ per year over their levels under the moderate regime (Table 9.6). Although huisache biomass decreased under the wet regime on the blackland type when averaged over the 25 years, it had higher biomass than under the moderate regime in the last year of each simulation (Year 25; Table 9.6). This suggests that huisache was rapidly increasing on this type during the later part of the 25-year succession.

Live oak increased or remained stable under the wet regime on all five of the vegetation types where it was included, whereas it decreased on all these types under the moderate regime (Tables 9.1 and 9.4). The average annual rainfall under the moderate regime was 36.8 inches and 42.3 inches under the wet regime. The transition between grassland and woodland occurs at about 38-40 inches average annual rainfall (Section 9.1.1.4). These simulation results suggest that the live oak woodlands in the central Texas Coast were probably established under a higher rainfall regime than currently exists as suggested by Drawe et al. (1978).

Smutgrass is an aggressive mid-seral non-native bunchgrass, best adapted to more mesic conditions, and that rapidly increases under disturbed conditions. It increased substantially on all three types where it was included in the simulations (blackland, claypan prairie, and loamy prairie; Tables 9.6 and 9.7) under the wet regime.

The initial species composition used in the Victoria County EDYS model assumed mid-seral conditions (Section 6.3 and Appendix Table C.2). Mid-seral grasslands in the Texas Coastal Prairies are dominated by mid-grasses, with substantial amounts of shortgrasses and small amounts of tallgrasses. As succession proceeds in these grasslands the shortgrasses are largely replaced by midgrasses and the amount of tallgrasses also increases. Successional dynamics, both succession and retrogression, often occur more rapidly on sandier soils than on adjacent clay soils. Therefore successional increases in midgrasses and tallgrasses would most likely occur on the sandy loam type under the wet regime.

This successional pattern did occur in the simulation of the sandy loam type under the wet regime. Midgrass biomass increased by 29% more than under the moderate regime when averaged over the 25 years of the simulation (Table 9.7) and increased four-fold over initial conditions (Table 9.1). Little bluestem, the dominant midgrass on this type, increased from an initial total aboveground biomass of 53 $g/m^2$ (Table 9.1) to a value of 548 $g/m^2$ at the end of the 25-year simulation (Table 9.7). Sideoats grama, another major midgrass on these prairies, increased from an initial value of 2 $g/m^2$ to a value of 273 $g/m^2$ after 25 years. The two major tallgrasses on this type, big bluestem and indiangrass, increased from an initial combined biomass of 2 $g/m^2$ to 40 $g/m^2$ in Year 25. Initially, the composition (% relative biomass) of these four species was 21% little bluestem, 1% sideoats grama, 0.4% big bluestem, and 0.4% indiangrass. After 25 years, the values increased to 54% little bluestem, 27% sideoats grama, 3% big bluestem, and 1% indiangrass.

The wet regime had minimal affect, compared to the moderate regime, on tree biomass in the loamy bottomland type (Table 9.8) because groundwater was readily available to the trees under the moderate regime. The primary impacts of the wet regime on the herbaceous community was to increase Johnsongrass, knotroot bristlegrass, and flatsedge, all three species which are well-adapted to moist conditions, and to decrease littletooth sedge and old-man's beard.

Gulf cordgrass and Olney bulrush were the species most affected by the wet regime on the salty bottomland type, both which increased substantially (14% and 90%, respectively; Table 9.8). Spiny aster decreased by 94% in response to increased competition from gulf cordgrass and bulrush. Huisache decreased slightly (1%) and mesquite increased slightly (4%) on this type under the wet regime.

### 9.1.2.3 Summary of Response to Rainfall

Overall, the vegetation response, both biomass and species composition, in the simulations reflected expected ecological responses. Total aboveground biomass, averaged over the six representative types, was lower (6%) under the dry rainfall regime and higher (9%) under the wet rainfall regime than under the moderate (baseline) rainfall regime at the end of 25 years (Table 9.9). The rainfall regimes had the least effect on trees, in large part because of the stabilizing effect of groundwater use by this lifeform. Midgrasses and grass-likes had lower biomass under the dry regime and higher biomass under the wet regime, as expected. Both of these herbaceous lifeforms are better adapted to mesic conditions. Shrub dynamics were dominated by Macartney rose and this species had lower biomass under the dry regime because of less available water but also had lower biomass under the higher regime because of competition from huisache and midgrasses. Shortgrasses and forbs had lower biomass under both dry and wet regimes, compared to the moderate regime, because of competitive differences among species in each of the two lifeforms.

Huisache increased in both biomass and percent composition as rainfall regime increased (Table 9.9). Although huisache can tolerate lower moisture levels, it is best adapted to relatively moist conditions and therefore it increased as the rainfall regime increased. Mesquite decreased under the wet regime, largely in response to increased competition from the more rapidly growing huisache. Mesquite is a more xeric species than huisache and Victoria County is approaching the

**Table 9.9 Aboveground biomass (g/m²), species composition (% relative biomass), and proportion of medium-regime biomass of major species at end of the 25-year simulation under three rainfall regimes, Victoria County EDYS model. Values averaged over the six types (Tables 9.6-9.8).**

| Lifeform/ | Aboveground Biomass | | | Species Composition | | | Ratio to Med-Regime Biomass | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Dry | Medium | Wet | Dry | Medium | Wet | Dry | Medium | Wet |
| **Trees** | | | | | | | | | |
| Huisache | 1861 | 2020 | 2329 | 40.1 | 41.0 | 43.5 | 0.921 | 1.000 | 1.153 |
| Sugar hackberry | 172 | 174 | 173 | 3.7 | 3.5 | 3.2 | 0.989 | 1.000 | 0.994 |
| Mesquite | 518 | 524 | 508 | 11.2 | 10.5 | 9.5 | 0.989 | 1.000 | 0.969 |
| Live oak | 1138 | 1132 | 1144 | 24.5 | 23.0 | 21.4 | 1.005 | 1.000 | 1.011 |
| **Shrubs** | | | | | | | | | |
| Macartney rose | 277 | 296 | 281 | 6.0 | 6.0 | 5.2 | 0.936 | 1.000 | 0.949 |
| **Midgrasses** | | | | | | | | | |
| Big bluestem | 2 | 2 | 6 | t | t | 0.1 | 1.000 | 1.000 | 3.000 |
| Sideoats grama | 7 | 15 | 47 | 0.2 | 0.3 | 0.9 | 0.467 | 1.000 | 3.133 |
| Little bluestem | 68 | 107 | 106 | 1.5 | 2.2 | 2.0 | 0.636 | 1.000 | 0.991 |
| Plains bristlegrass | 6 | 6 | 13 | 0.1 | 0.1 | 0.2 | 1.000 | 1.000 | 2.166 |
| Johnsongrass | 2 | 4 | 7 | t | 0.1 | 0.1 | 0.500 | 1.000 | 1.450 |
| Gulf cordgrass | 118 | 98 | 126 | 2.5 | 2.0 | 2.4 | 1.204 | 1.000 | 1.286 |
| Smutgrass | 6 | 8 | 49 | 0.1 | 0.2 | 0.9 | 0.750 | 1.000 | 6.125 |
| **Shortgrasses** | | | | | | | | | |
| Brownseed paspalum | 13 | 15 | 25 | 0.3 | 0.3 | 0.5 | 0.867 | 1.000 | 1.667 |
| Knotroot bristlegrass | 30 | 7 | 23 | 0.6 | 0.1 | 0.4 | 4.286 | 1.000 | 3.286 |
| Texas wintergrass | 9 | t | 3 | 0.2 | t | 0.1 | ----- | ----- | ----- |
| **Grass-Likes** | | | | | | | | | |
| Littletooth sedge | t | 25 | 1 | t | 0.3 | t | 0.000 | 1.000 | 0.040 |
| Flatsedge | 14 | 12 | 56 | 0.3 | 0.2 | 1.0 | 1.167 | 1.000 | 4.667 |
| Olney bulrush | 9 | 12 | 44 | 0.2 | 0.2 | 0.8 | 0.750 | 1.000 | 3.667 |
| **Forbs** | | | | | | | | | |
| Spiny aster | 7 | 31 | 1 | 0.2 | 0.6 | t | 0.226 | 1.000 | 0.032 |
| Ragweed | 81 | 57 | 45 | 1.7 | 1.2 | 0.8 | 1.421 | 1.000 | 0.789 |
| Old-mans beard | 5 | 63 | 53 | 0.1 | 1.3 | 1.0 | 0.079 | 1.000 | 0.841 |
| Bush sunflower | 1 | 5 | 1 | t | 0.1 | t | 0.200 | 1.000 | 0.200 |
| **By Lifeforms** | | | | | | | | | |
| Trees | 3869 | 4031 | 4336 | 83.4 | 81.8 | 80.9 | 0.960 | 1.000 | 1.076 |
| Shrubs and Vines | 377 | 406 | 391 | 8.1 | 8.2 | 7.3 | 0.929 | 1.000 | 0.963 |
| Midgrasses | 214 | 249 | 364 | 4.6 | 5.1 | 6.8 | 0.859 | 1.000 | 1.462 |
| Shortgrasses | 61 | 30 | 58 | 1.3 | 0.6 | 1.1 | 2.033 | 1.000 | 1.933 |
| Grass-likes | 23 | 49 | 101 | 0.5 | 1.0 | 1.9 | 0.469 | 1.000 | 2.061 |
| Forbs | 98 | 162 | 109 | 2.1 | 3.3 | 2.0 | 0.605 | 1.000 | 0.673 |
| Total aboveground | 4641 | 4927 | 5359 | 100.0 | 100.0 | 100.0 | 0.942 | 1.000 | 1.088 |

eastern (higher rainfall) limit of the historic distribution of mesquite (Benson 1941; McLendon 1979; Elias 1980). It is abundant from Goliad and Refugio Counties westward but bcomes a minor species from Matagorda County eastward to western Louisiana. Even where mesquite is abundant, it does not necessarily increase during wet periods because of competition from other species. For example, relatively wet conditions occurred in South Texas beginning in 1957, following the drought of 1950-56. Despite above-average rainfall, mesquite decreased in cover on the Welder Wildlife Refuge in San Patricio County during the 15 years following the drought whereas huisache increased (Drawe et al. 1978). Mesquite also decreased in shrub clusters on the La Copita Experimental Range in Jim Wells County, a drier part of South Texas than San Patricio County, although associated woody species including huisache increased during the wetter period following the drought of the 1950s (Archer et al. 1988). Live oak increased in biomass under the wet regime simulation, indicating a favorable response to increased moisture, but the increase was not as substantial as that of huisache. Therefore, the relative composition of live oak decreased along the simulated moisture gradient.

Most midgrasses decreased in biomass under the dry regime and increased under the wet regime (Table 9.9). An exception was little bluestem, which decreased slightly under the wet regime. The 42-inch average rainfall under the wet regime was somewhat higher than typical for little bluestem dominated grasslands. As average annual rainfall exceeds 32-35 inches, the shift is from midgrass-dominated to tallgrass-dominated grasslands (Table 9.2). Smutgrass was a midgrass particularly favored by the wet regime. This species is well-adpated to wetter conditions, both as higher rainfall and saturated soils. Smutgrass is found from the Central Texas Coast eastward to Florida and Virginia and throughout Central America and many parts of South America (Gould 1975).

Of the major shortgrasses, brownseed paspalum increased as the rainfall regime increased (Table 9.9). Knotroot bristlegrass had biomass values higher under both the wet regime (because of its adaptation to relatively wet conditions) and the dry regime (because of less competition from other herbaceous species) than under the moderate regime. Texas wintergrass is a relatively xeric species, compared to other species in the simulation, and its biomass was highest under the dry regime. Flatsedge and Olney bulrush are grass-likes that are well-adapted to wet (including saturated) conditions and both of these species had substantial increases in biomass under the wet regime.

### 9.1.3 Effect of Livestock Grazing

The effect of livestock grazing on vegetation dynamics was simulated under two scenarios: 1) cattle grazing at a moderate stocking rate (Table 7.2 and Appendix Table D.2) and 2) cattle grazing at a heavy stocking rate (50% increase over the moderate rate). Both grazing scenarios used the moderate rainfall regime.

#### 9.1.3.1 Moderate Stocking Rate

Vegetation response varied by type under a simulated moderate stocking rate by cattle (Table 9.10). Grass aboveground biomass decreased, compared to the ungrazed scenario, on the sandy loam, loamy bottomland, and salty bottomland types, but increased on the blackland, claypan prairie, and loamy prairie types. Vegetation growing on coarse-textured soils tends to respond more quickly to changes in environmental conditions, both favorable and unfavorable, than vegetation growing on heavier (e.g., clay) textured soils. The major component of the high grass biomass on the ungrazed sandy loam type was little bluestem (Table 9.1). The initial value for this midgrass on this type was 123 g/m$^2$ under ungrazed conditions and then increased rapidly by Year 15. Little bluestem is a relatively preferred species by cattle on this type and under the grazing scenario it received substantial grazing pressure, especially because it comprised over half of the forage biomass initially (Table 9.1). Because of this grazing pressure, little bluestem was not able to increase rapidly. Instead, the unpalatable species ragweed increased because of reduced competition from the grasses. Consequently at the end of 25 years, ragweed aboveground biomass was seven times as high under grazing than without grazing. A similar condition existed on the loamy bottomland type. On this type, grass biomass was relatively low initially and decreased from Year 10 even under ungrazed conditions because of competition from forbs and grass-likes (Table 9.4). When grazing was added, the grasses became even less competitive and ragweed and flatsedge increased substantially. Under ungrazed conditions, old-man's beard, an aggressive vine-like forb, increased over the 25 years. It did not increase under grazed conditions because of heavy use by both deer and cattle. Old-man's beard is not a preferred forage species by cattle but cattle will consume it when more preferred species are in low abundance (Smith and McLendon 1981), as happened on the loamy bottomland type over time. Gulf cordgrass was the only forage species in abundance on the salty bottomland type and it was heavily utilized by cattle under the grazed scenario, thereby reducing its biomass compared to ungrazed conditions.

Both huisache and mesquite increased with grazing in comparison to ungrazed on the three types where grass biomass decreased (Table 9.10). This suggests that even moderate-level grazing is likely to increase the rate of increase in these two species when grass biomass is low. Conversely, huisache decreased with grazing on the blackland and loamy prairie sites, compared to ungrazed conditions, and grazing had little effect on huisache on the claypan prairie type. Mesquite biomass increased more under moderate grazing than under ungrazed conditions on all types except blackland, where grazing had little effect on mesquite abundance.

Grass biomass increased under moderate grazing on the blackland and loamy prairie types, compared to the ungrazed scenario. On the loamy prairie type, most of the increase came from little bluestem (Table 9.10). In the absence of grazing, little bluestem increased on these two types for 15 years and then decreased as huisache increased (Table 9.1). Although little bluestem also increased on the blackland type with grazing, most of the increase in grasses on this type came from purple threeawn and buffalograss. These are mid-seral species on this type and both tolerate moderate to heavy grazing by cattle. Silver bluestem and sideoats grama were also favored by grazing on the blackland type and these two midgrasses are more tolerant of grazing than little bluestem. Three tallgrasses were included in these simulations. Of these, big bluestem was favored on the blackland type by grazing and all three were strongly favored on the loamy prairie type. Ungrazed, or unburned, prairie grasses tend to decrease in productivity over time because of a buildup in senescent and dead biomass (litter). Light to moderate grazing reduces this buildup and gives the grasses somewhat of a pruning effect, thereby increasing productivity. This is what occurred in the grazing simulation. Midgrass biomass (including the three tallgrass species) almost tripled on the blackland type over the 25-year grazing scenario compared to ungrazed and increased more than five-fold on the loamy prairie site. This increase in grass biomass reduced the amount of forbs produced and reduced, but did not stop, the rate of increase of huisache. Compared to initial conditions (Table 9.1), huisache still increased by 73% after 25 years on the grazed blackland type and by 26% on the loamy prairie type.

**Table 9.10 Comparison of aboveground biomass ($g/m^2$), by lifeform and by major species, at the end of 25-year simulations for six vegetation types under grazed (GRZ; moderate stocking rate) and ungrazed (UNG) conditions, Victoria County EDYS model, moderate rainfall regime and 38% initial canopy cover of woody species.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GRZ | UNG | GRZ | UNG | GRZ | UNG | GRZ | UNG | GRZ | UNG | GRZ | UNG |
| Trees | 2357 | 3549 | 3239 | 3189 | 2923 | 4118 | 4267 | 4223 | 3668 | 3800 | 8574 | 5306 |
| Shrubs and vines | 422 | 544 | 654 | 931 | 297 | 340 | 256 | 177 | 334 | 352 | 91 | 88 |
| Midgrasses | 121 | 47 | 18 | 19 | 715 | 139 | 55 | 668 | 10 | 34 | 477 | 585 |
| Shortgrasses | 455 | 17 | 51 | 16 | 3 | 69 | 7 | 30 | 1 | 26 | t | 22 |
| Grass-likes | 11 | 3 | 120 | 8 | t | t | --- | --- | 416 | 211 | 13 | 74 |
| Forbs | 5 | 20 | 1 | 4 | 4 | 4 | 533 | 71 | 493 | 667 | 88 | 205 |
| Total aboveground | 3371 | 4180 | 4083 | 4167 | 3942 | 4670 | 5118 | 5169 | 4922 | 5090 | 9243 | 6280 |
| Huisache | 1533 | 2700 | 2179 | 2157 | 927 | 2121 | 110 | 99 | 215 | 196 | 4989 | 4847 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 891 | 896 | --- | --- |
| Sugar hackberry | 60 | 79 | --- | --- | 150 | 201 | 149 | 187 | 448 | 577 | --- | --- |
| Mesquite | 675 | 678 | 132 | 113 | 954 | 866 | 955 | 802 | 274 | 226 | 3585 | 459 |
| Post oak | --- | --- | --- | --- | --- | --- | 192 | 190 | --- | --- | --- | --- |
| Live oak | 89 | 92 | 928 | 919 | 892 | 930 | 2861 | 2945 | 1840 | 1905 | --- | --- |
| Blackbrush | --- | --- | --- | --- | --- | --- | 38 | 40 | --- | --- | --- | --- |
| Baccharis | 36 | 67 | 49 | 108 | --- | --- | --- | --- | --- | --- | --- | --- |
| Sea oxeye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 88 | 85 |
| Granjeno | --- | --- | --- | --- | --- | --- | 218 | 137 | --- | --- | --- | --- |
| Macartney rose | 372 | 458 | 602 | 820 | 297 | 340 | --- | --- | 148 | 157 | --- | --- |
| Rattlepod | --- | --- | 3 | 3 | --- | --- | --- | --- | 1 | 1 | 3 | 3 |
| Greenbriar | 14 | 19 | --- | --- | --- | --- | --- | --- | 4 | 8 | --- | --- |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 181 | 186 | --- | --- |
| Big bluestem | 11 | 1 | t | t | 92 | 2 | t | 7 | 1 | 1 | --- | --- |
| Bushy bluestem | 1 | 1 | 1 | 1 | 1 | 2 | --- | --- | 2 | 10 | --- | --- |
| Silver bluestem | 30 | 6 | --- | --- | --- | --- | 6 | 4 | 2 | 2 | --- | --- |
| Sideoats grama | 11 | 2 | --- | --- | --- | --- | 4 | 86 | 1 | 4 | --- | --- |
| Panamerican balsamscale | -- | --- | --- | --- | --- | --- | 6 | 16 | --- | --- | --- | --- |
| Switchgrass | 3 | 1 | 1 | t | 45 | 1 | --- | --- | 1 | 3 | --- | --- |
| Little bluestem | 63 | 15 | 14 | 11 | 565 | 94 | 36 | 518 | 2 | 4 | t | t |
| Plains bristlegrass | 0 | 1 | --- | --- | --- | --- | 0 | 28 | 0 | 4 | --- | --- |
| Indiangrass | 2 | 1 | 1 | t | 12 | 1 | 2 | 7 | 1 | 1 | --- | --- |
| Johnsongrass | 0 | 2 | --- | --- | 0 | 15 | --- | --- | 0 | 5 | --- | --- |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 477 | 585 |
| Tall dropseed | t | 1 | 1 | 1 | --- | --- | 1 | 1 | --- | --- | --- | --- |
| Smutgrass | 0 | 16 | 0 | 6 | 0 | 24 | --- | --- | --- | --- | --- | --- |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 6 | 7 | --- | --- | --- | --- |
| Purple threeawn | 277 | 3 | --- | --- | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Buffalograss | 176 | 1 | --- | --- | --- | --- | t | t | t | t | t | t |
| Saltgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0 | 21 |
| Longtom | 0 | 2 | 0 | 3 | t | 3 | --- | --- | 0 | 2 | --- | --- |
| Brownseed paspalum | 0 | 9 | 0 | 2 | 0 | 37 | 0 | 20 | 0 | 23 | --- | --- |
| Knotroot bristlegrass | 1 | 1 | 50 | 11 | 1 | 27 | 1 | t | 1 | 1 | --- | --- |
| Littletooth sedge | --- | --- | 92 | 7 | t | t | --- | --- | 0 | 2 | --- | --- |
| Flatsedge | 11 | 3 | 28 | 1 | --- | --- | --- | --- | 416 | 284 | --- | --- |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 13 | 74 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 2 | 3 | 7 | 182 |
| Ragweed | 2 | t | 1 | t | 2 | t | 298 | 41 | 490 | 300 | --- | --- |
| Wild indigo | 0 | 3 | 0 | 4 | 0 | 3 | --- | --- | 0 | 1 | --- | --- |
| Old-man's beard | t | 16 | --- | --- | --- | --- | --- | --- | 1 | 363 | --- | --- |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 81 | 23 |
| Bush sunflower | 3 | 1 | --- | --- | 2 | t | 235 | 30 | --- | --- | --- | --- |

A trace amount (< 0.5 $g/m^2$) is indicated by a "t". Dashes (---) indicate the species was not included in that type.

Grass biomass decreased on the grazed claypan prairie type compared to initial conditions (Table 9.1), but the decrease was less than under ungrazed conditions (Table 9.10). This was primarily because of an increase in knotroot bristlegrass under the grazed scenario. Total herbaceous biomass on the grazed claypan prairie was similar to the initial value (190 and 185 g/m$^2$, respectively), but most of herbaceous biomass under grazing was from three low preference species: knotroot bristlegrass, littletooth sedge, and flatsedge. Huisache did not increase as much on this type when grazed than when ungrazed, but mesquite increased more. In addition to some increased competition from the herbaceous species (190 g/m$^2$ grazed and 47 g/m$^2$ ungrazed, Table 9.10), huisache also was likely more affected by browsing under the grazing regime. Cattle do not browse large amounts of huisache but they do consume some, especially in late winter and early spring (Smith and McLendon 1981).

#### 9.1.3.2 Heavy Stocking Rate

The expected response from heavy grazing was that grass biomass, especially midgrasses, would decrease in comparison with moderate grazing and that biomass of trees, especially huisache and mesquite, and unpalatable forbs would increase. This did happen in the simulations (Table 9.11). Heavy grazing decreased grass biomass on four of the six types. Overall, midgrass biomass decreased 15% under heavy grazing compared to moderate grazing, although midgrass biomass increased slightly on the sandy loam and loamy bottomland types. Huisache increased 43% more under heavy grazing than under moderate grazing on the three types where it was a major species (blackland, claypan prairie, loamy prairie). Relative to its response under moderate grazing, mesquite increased under heavy grazing on blackland and loamy prairie types, decreased slightly on the claypan prairie, sandy loam, and loamy bottomland types, and increased less on the salty bottomland than under moderate grazing.

Most midgrasses had less biomass under heavy grazing than under moderate grazing (Table 9.11). Averaged over the five types, excluding the salty bottomland type which only had significant amounts of gulf cordgrass, most midgrasses decreased under heavy grazing compared to moderate grazing. On average, big bluestem decreased by 63%, silver bluestem by 60%, switchgrass by 58%, indiangrass by 33%, sideoats grama by 25%, and little bluestem by 3%, compared to their values under moderate grazing. On the salty bottomland type, gulf cordgrass decreased under heavy grazing by 14% compared to moderate grazing, the semi-shrub sea oxeye increased by 6%, glasswort (*Salicornia virginica*) increased by 35%, and Olney bulrush tripled in biomass compared to its value under moderate grazing.

### 9.1.4 Response to Brush Management

Five brush management scenarios were simulated. In each case, the basic brush treatment was the same: 90% of the aboveground biomass of the target woody species and 50% of the aboveground herbaceous biomass were removed from all non-urban areas. Brush control was simulated to occur in March of Year 1. Pecan was excluded from the brush control operation, assuming that these trees would be left as desirable species. Only 50% of live oak biomass was removed in order to allow large live oak trees to remain on the landscape. The removal of 50% of herbaceous vegetation was included because the brush management method being simulated was root-plowing, which disturbs the soil surface thereby removing a portion of established

**Table 9.11 Aboveground biomass (g/m²), by lifeform and by major species, at the end of 25-year simulations for six vegetation types under moderate (MOD) and heavy (HVY) stocking rates, Victoria County EDYS model, moderate rainfall regime and 38% initial cover of woody species.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOD | HVY | MOD | HVY | MOD | HVY | MOD | HVY | MOD | HVY | MOD | HVY |
| Trees | 2357 | 3769 | 3239 | 3649 | 2923 | 3310 | 4267 | 4286 | 3668 | 3664 | 8574 | 7959 |
| Shrubs and vines | 422 | 436 | 654 | 666 | 297 | 298 | 256 | 239 | 334 | 337 | 91 | 96 |
| Midgrasses | 121 | 57 | 18 | 15 | 715 | 615 | 55 | 73 | 10 | 17 | 477 | 412 |
| Shortgrasses | 455 | 18 | 51 | 30 | 3 | 3 | 7 | 8 | 1 | 1 | t | t |
| Grass-likes | 11 | 12 | 120 | 41 | t | t | --- | --- | 416 | 256 | 13 | 40 |
| Forbs | 5 | 13 | 1 | t | 4 | 3 | 533 | 517 | 493 | 602 | 88 | 119 |
| Total aboveground | 3371 | 4305 | 4083 | 4401 | 3942 | 4229 | 5118 | 5123 | 4922 | 4877 | 9243 | 8626 |
| Huisache | 1533 | 2783 | 2179 | 2605 | 927 | 1254 | 110 | 110 | 215 | 208 | 4989 | 4989 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 891 | 892 | --- | --- |
| Sugar hackberry | 60 | 60 | --- | --- | 150 | 149 | 149 | 149 | 448 | 449 | --- | --- |
| Mesquite | 675 | 836 | 132 | 119 | 954 | 1004 | 955 | 936 | 274 | 237 | 3585 | 2970 |
| Post oak | --- | --- | --- | --- | --- | --- | 192 | 192 | --- | --- | --- | --- |
| Live oak | 89 | 90 | 928 | 925 | 892 | 903 | 2861 | 2899 | 1840 | 1878 | --- | --- |
| Blackbrush | --- | --- | --- | --- | --- | --- | 38 | 38 | --- | --- | --- | --- |
| Baccharis | 36 | 34 | 49 | 50 | --- | --- | --- | --- | --- | --- | --- | --- |
| Sea oseye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 88 | 93 |
| Granjeno | --- | --- | --- | --- | --- | --- | 218 | 201 | --- | --- | --- | --- |
| Macartney rose | 372 | 375 | 602 | 613 | 297 | 298 | --- | --- | 148 | 149 | --- | --- |
| Greenbriar | 14 | 27 | --- | --- | --- | --- | --- | --- | 4 | 4 | --- | --- |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 181 | 183 | --- | --- |
| Big bluestem | 11 | 2 | t | t | 92 | 36 | t | t | 1 | 1 | --- | --- |
| Bushy bluestem | 1 | 1 | 1 | 1 | 1 | 1 | --- | --- | 2 | 4 | --- | --- |
| Silver bluestem | 30 | 8 | --- | --- | --- | --- | 6 | 5 | 2 | 2 | --- | --- |
| Sideoats grama | 11 | 4 | --- | --- | --- | --- | 4 | 5 | 1 | 3 | --- | --- |
| Panamerican balsamscale | -- | --- | --- | --- | --- | --- | 6 | 8 | --- | --- | --- | --- |
| Switchgrass | 3 | 2 | 1 | t | 45 | 17 | --- | --- | 1 | 2 | --- | --- |
| Little bluestem | 63 | 38 | 14 | 12 | 565 | 554 | 36 | 52 | 2 | 4 | t | t |
| Indiangrass | 2 | 1 | 1 | 1 | 12 | 7 | 2 | 2 | 1 | 1 | --- | --- |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 477 | 412 |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 6 | 7 | --- | --- | --- | --- |
| Purple threeawn | 277 | 7 | --- | --- | 1 | 1 | --- | --- | --- | --- | --- | --- |
| Buffalograss | 176 | 9 | --- | --- | --- | --- | t | t | t | t | t | t |
| Knotroot bristlegrass | 1 | 1 | 50 | 30 | 1 | 2 | 1 | 1 | 1 | 1 | --- | --- |
| Littletooth sedge | --- | --- | 92 | 35 | t | t | --- | --- | 0 | t | --- | --- |
| Flatsedge | 11 | 12 | 28 | 6 | --- | --- | --- | --- | 416 | 256 | --- | --- |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 13 | 40 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 2 | 2 | 7 | 9 |
| Ragweed | 2 | 1 | 1 | t | 2 | 2 | 298 | 280 | 490 | 369 | --- | --- |
| Old-man's beard | t | 10 | --- | --- | --- | --- | --- | --- | 1 | 231 | --- | --- |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 81 | 110 |
| Bush sunflower | 3 | 2 | --- | --- | 2 | 1 | 235 | 237 | --- | --- | --- | --- |

A trace amount (< 0.05 g/m²) is indicated by a "t". Dashes (---) indicate the species was not included in that type.

herbaceous plants. Grazing by cattle was maintained at a moderate stocking rate under all five of the brush control scenarios.

The five brush management scenarios were: 1) the only woody species removed (90%) was huisache, moderate rainfall regime, 2) the only woody species removed (90%) was Macartney rose, moderate rainfall regime, 3) 90% of all woody species were removed, moderate rainfall regime, 4) 90% of all woody species were removed, dry rainfall regime, and 5) 90% of all woody species removed, wet rainfall regime. In the last three scenarios, pecan was not removed and only 50% of live oak was removed.

In these five scenarios, 90% of the target species were removed from all non-urban areas. In actual practice, this would not likely be the case on a county-wide basis. In practice, different landowners throughout the county would make brush control decisions based on conditions specific to their particular land and management goals and therefore the density of brush treated would likely vary across the county. However, simulating treatment on the target species throughout the county provides an estimate of the maximum effect that brush control might have on ecohydrology, given the specific amount of area treated.

Each of the affected vegetation-soil cell types responded differently to the brush management scenarios, as would be expected because of the ecological diversity. The ecological responses are integrations of the vegetation and land-use mosaics over each watershed. However, reporting vegetation responses for each vegetation type would be a substantial effort. Instead of reporting each individually, results of vegetation responses on four major vegetation types are presented to illustrate the effects of the brush management on vegetation.

#### 9.1.4.1 Removal (90%) of Huisache

The removal of 90% of huisache in the first year of the simulation resulted in small increases in most other trees, increases in Macartney rose and baccharis, and increases in herbaceous types other than forbs (Table 9.12). Sugar hackberry was the tree species that increased the most following huisache control, whereas there was a decrease in mesquite. Midgrass biomass almost doubled because of huisache control. However most of the increase resulted from increases in earlier-seral species, especially smutgrass and Johnsongrass. Most mid- and late-seral midgrasses also increased following huisache control but their increases were less than for smutgrass and Johnsongrass. Little bluestem increased by 11% overall, but tripled in biomass on the sandy loam type. Bushy bluestem, plains bristlegrass, sideoats grama, and Panamerican balsamscale also increased overall, while big bluestem and switchgrass decreased. The midgrasses that increased, including smutgrass, are mostly mid-seral species except for little bluestem on the sandy loam type. This increase in mid-seral grasses, but not late-seral species, suggests that 25 years is not sufficiently long for the herbaceous components of most of these types to return to late-seral conditions. This conclusion is supported by the dynamics of other herbaceous species. Of the shortgrasses, brownseed paspalum and longtom increased substantially following huisache control and both of these are mid-seral species on most of these types. Knotroot bristlegrass also increased and it is an earlier seral species than brownseed paspalum and longtom. There was also a large increase in saltgrass on the salty bottomland type and this is a common sub-dominant species on this type. The sedges, ragweed, and bush sunflower all decreased following huisache control and all of these are early-seral or early mid-seral species. Old-man's beard also increased on the loamy bottomland and blackland types in response to reduced competition from huisache.

**Table 9.12 Effect of removal of 90% of huisache biomass in March of Year 1 on mean aboveground biomass (g/m², end of growing season), by lifeform and by major species, on six vegetation types (38% initial woody plant cover) averaged over 25 years, Victoria County EDYS model. BC = removal of huisache, NO = no removal.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO |
| Trees | 882 | 2078 | 1186 | 2534 | 2192 | 2912 | 4442 | 4472 | 3912 | 3950 | 605 | 6259 | 2203 | 3701 |
| Shrubs and vines | 735 | 654 | 1284 | 1013 | 488 | 441 | 244 | 291 | 514 | 469 | 125 | 122 | 565 | 498 |
| Midgrasses | 473 | 132 | 232 | 45 | 552 | 503 | 329 | 85 | 85 | 34 | 406 | 345 | 346 | 191 |
| Shortgrasses | 103 | 266 | 144 | 72 | 103 | 16 | 41 | 23 | 46 | 14 | 17 | 3 | 76 | 66 |
| Grass-likes | 72 | 23 | 73 | 134 | 1 | 1 | --- | --- | 142 | 289 | 265 | 27 | 92 | 79 |
| Forbs | 68 | 53 | 25 | 21 | 30 | 52 | 250 | 480 | 551 | 480 | 136 | 87 | 177 | 196 |
| Total Aboveground | 2333 | 3206 | 2944 | 3819 | 3366 | 3925 | 5306 | 5351 | 5250 | 5236 | 1554 | 6843 | 3459 | 4731 |
| Huisache | 84 | 1259 | 69 | 1411 | 66 | 839 | 12 | 113 | 23 | 227 | 150 | 4759 | 67 | 1435 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 946 | 939 | --- | --- | 158 | 157 |
| Sugar hackberry | 91 | 68 | --- | --- | 222 | 174 | 217 | 172 | 661 | 541 | --- | --- | 199 | 159 |
| Mesquite | 612 | 656 | 149 | 136 | 919 | 944 | 911 | 961 | 256 | 274 | 455 | 1500 | 550 | 745 |
| Post oak | --- | --- | --- | --- | --- | --- | 219 | 220 | --- | --- | --- | --- | 37 | 37 |
| Live oak | 95 | 95 | 968 | 987 | 985 | 955 | 3083 | 3006 | 2026 | 1969 | --- | --- | 1193 | 1169 |
| Blackbrush | --- | --- | --- | --- | --- | --- | 61 | 56 | --- | --- | --- | --- | 10 | 9 |
| Baccharis | 94 | 74 | 178 | 94 | --- | --- | --- | --- | --- | --- | --- | --- | 45 | 28 |
| Sea oxeye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 108 | 106 | 18 | 18 |
| Granjeno | --- | --- | --- | --- | --- | --- | 183 | 235 | --- | --- | --- | --- | 31 | 39 |
| Macartney rose | 603 | 552 | 1091 | 904 | 488 | 441 | --- | --- | 249 | 220 | --- | --- | 405 | 353 |
| Rattlepod | --- | --- | 15 | 15 | --- | --- | --- | --- | 6 | 6 | 17 | 16 | 6 | 6 |
| Greenbriar | 38 | 28 | --- | --- | --- | --- | --- | --- | 20 | 10 | --- | --- | 10 | 6 |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 239 | 233 | --- | --- | 40 | 39 |
| Big bluestem | 2 | 4 | t | t | 4 | 22 | 1 | t | 1 | 1 | --- | --- | 1 | 5 |
| Bushy bluestem | 8 | 6 | 8 | 6 | 9 | 6 | --- | --- | 33 | 10 | --- | --- | 10 | 5 |
| Silver bluestem | 17 | 20 | --- | --- | --- | --- | 7 | 8 | 3 | 3 | --- | --- | 5 | 5 |
| Sideoats grama | 6 | 13 | --- | --- | --- | --- | 18 | 4 | 7 | 6 | --- | --- | 5 | 4 |
| Panamerican balsamscale | - | --- | --- | --- | --- | --- | 43 | 13 | --- | --- | --- | --- | 7 | 2 |
| Switchgrass | 3 | 4 | 1 | 1 | 4 | 20 | --- | --- | 4 | 4 | --- | --- | 2 | 5 |
| Little bluestem | 60 | 80 | 27 | 32 | 353 | 446 | 238 | 57 | 10 | 8 | 1 | t | 115 | 104 |
| Plains bristlegrass | 7 | t | --- | --- | --- | --- | 16 | t | 12 | t | --- | --- | 6 | t |
| Indiangrass | 2 | 2 | 1 | 1 | 3 | 8 | 5 | 2 | 2 | 1 | --- | --- | 2 | 2 |
| Johnsongrass | 10 | t | --- | --- | 76 | t | --- | --- | 12 | t | --- | --- | 16 | t |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 405 | 345 | 68 | 58 |
| Smutgrass | 356 | 1 | 193 | 3 | 103 | 1 | --- | --- | --- | --- | --- | --- | 109 | 1 |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 18 | 12 | --- | --- | --- | --- | 3 | 2 |
| Purple threeawn | 38 | 149 | --- | --- | 2 | 2 | --- | --- | --- | --- | --- | --- | 7 | 25 |
| Buffalograss | 26 | 102 | --- | --- | --- | --- | 2 | 2 | 3 | 3 | t | t | 5 | 18 |
| Bermudagrass | 3 | 4 | 3 | 3 | 1 | 1 | 4 | 4 | 2 | 2 | 2 | 2 | 3 | 3 |
| Saltgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 15 | 1 | 3 | t |
| Longtom | 6 | t | 6 | 1 | 8 | 1 | --- | --- | 3 | t | --- | --- | 4 | t |
| Brownseed paspalum | 20 | t | 3 | t | 71 | 1 | 13 | t | 30 | t | --- | --- | 23 | t |
| Thin paspalum | 5 | 5 | 2 | 2 | 4 | 4 | 2 | 2 | --- | --- | --- | --- | 2 | 2 |
| Knotroot bristlegrass | 4 | 5 | 129 | 65 | 16 | 6 | 1 | 2 | 7 | 8 | --- | --- | 26 | 14 |
| Littletooth sedge | --- | --- | 2 | 86 | 1 | 1 | --- | --- | 12 | 12 | --- | --- | 3 | 17 |
| Flatsedge | 72 | 23 | 71 | 48 | --- | --- | --- | --- | 130 | 277 | --- | --- | 46 | 58 |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 265 | 27 | 44 | 5 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 6 | 5 | 3 | 7 | 2 | 2 |
| Ragweed | 21 | 31 | 16 | 18 | 20 | 36 | 178 | 315 | 345 | 468 | --- | --- | 97 | 145 |
| Wild indigo | 6 | 1 | 8 | 2 | 6 | 1 | --- | --- | 1 | t | --- | --- | 4 | 1 |
| Old-man's beard | 29 | 2 | --- | --- | --- | --- | --- | --- | 199 | 7 | --- | --- | 36 | 2 |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 133 | 80 | 22 | 13 |
| Bush sunflower | 10 | 16 | --- | --- | 4 | 15 | 72 | 165 | --- | --- | --- | --- | 14 | 33 |

Dashes (---) indicate the species was not included in the simulation for that type. Trace (<0.5 g/m²) indicated by "t".

### 9.1.4.2 Removal (90%) of Macartney rose

The removal of 90% of Macartney rose the first year of the simulation had a similar, but lesser, effect on vegetation dynamics than did removal of huisache. Shrub biomass was reduced substantially because of the removal of most Macartney rose, tree biomass increased by a small amount, midgrass biomass increased by 22%, but biomass of other herbaceous lifeforms decreased (Table 9.13). Most of the increased tree biomass was from huisache and sugar hackberry. Mesquite biomass decreased, as it did when huisache was removed. Most of the increase in midgrass biomass was from increases in smutgrass, Johnsongrass, and gulf cordgrass. Although no Macartney rose was included in the salty bottomland type, this type was affected hydrologically by Macartney rose removal in adjacent types. Plains bristlegrass, sideoats grama, and bushy bluestem were also favored by Macartney rose removal, but little bluestem, big bluestem, silver bluestem, and switchgrass were adversely affected. Brownseed paspalum, longtom, and saltgrass were favored in this scenario, but purple threeawn and buffalograss had lower biomass. Removal of Macartney rose favored littletooth sedge, spiny aster, old-man's beard, and wild indigo, but the biomass of flatsedge, ragweed, and bush sunflower were reduced. This scenario removed an annual average of about 300 g/m$^2$ of Macartney rose biomass but huisache increased almost two-thirds of this amount, thereby reducing the benefit of Macartney rose control without a corresponding removal of huisache.

### 9.1.4.3 Removal (90%) of Woody Species, Moderate Rainfall Regime

In addition to the reduction in woody species biomass, this brush control scenario resulted in an increase in biomass of grasses and grass-likes and a small decrease in forb biomass when averaged over the six types and over the 25 years of the simulation (Table 9.14). Most of the increased midgrass biomass was from smutgrass. Other midgrasses that increased were Johnsongrass, plains bristlegrass, little bluestem, bushy bluestem, sideoats grama, and indiangrass. Panamerican balsamscale and gulf cordgrass were simulated on only two of the types, and both of these species increased substantially on their respective types. Most species varied in their response in relation to community type. For example, big bluestem decreased overall following brush control but it increased on the sandy loam type. Little bluestem decreased on the blackland and loamy prairie types but increased on the other four types. These different responses were the result of differences in environmental conditions among the types, especially differences in soils and competing species.

Brownseed paspalum and knotroot bristlegrass were the primary shortgrasses that increased following brush control (Table 9.14). Purple threeawn and buffalograss decreased in biomass because of increased competition from the midgrasses. Most of the purple threeawn and buffalograss occurred on the blackland type and smutgrass increased substantially on this type. Flatsedge also increased on this type and little bluestem, silver bluestem, and sideoats grama decreased substantially. The species that increased, smutgrass and flatsedge, are less palatable to cattle than the species that decreased and the two increaser species are also strong competitors. Among the forbs, old-man's beard was strongly favored by brush control, especially on the loamy bottomland type where it is especially well-adapted. Ragweed and bush sunflower, both relatively early-seral species, decreased following brush control, primarily because of increased competition from little bluestem on the sandy loam site and old-man's beard on the loamy

**Table 9.13 Effect of removal of 90% of Macartney rose biomass in March of Year 1 on aboveground biomass (g/m$^2$, end of growing season), by lifeform and by major species, on six vegetation types (38% initial woody plant cover) averaged over 25 years, Victoria County EDYS model. BC = removal of Macartney rose, NO = no removal.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO |
| Trees | 2586 | 2078 | 2694 | 2534 | 3454 | 2912 | 4547 | 4472 | 4101 | 3950 | 5095 | 6259 | 3746 | 3701 |
| Shrubs and vines | 201 | 654 | 314 | 1013 | 61 | 441 | 240 | 291 | 290 | 469 | 119 | 122 | 204 | 498 |
| Midgrasses | 125 | 132 | 84 | 45 | 242 | 503 | 328 | 85 | 77 | 34 | 546 | 345 | 234 | 191 |
| Shortgrasses | 69 | 266 | 53 | 72 | 114 | 16 | 53 | 23 | 58 | 14 | 33 | 3 | 63 | 66 |
| Grass-likes | 21 | 23 | 40 | 134 | 1 | 1 | --- | --- | 201 | 289 | 44 | 27 | 51 | 79 |
| Forbs | 43 | 53 | 20 | 21 | 27 | 52 | 241 | 480 | 507 | 480 | 109 | 87 | 158 | 196 |
| Total aboveground | 3045 | 3206 | 3205 | 3819 | 3899 | 3925 | 5409 | 5351 | 5234 | 5236 | 5946 | 6843 | 4456 | 4731 |
| Huisache | 1780 | 1259 | 1582 | 1411 | 1360 | 839 | 109 | 113 | 218 | 227 | 4676 | 4759 | 1621 | 1435 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 944 | 939 | --- | --- | 157 | 157 |
| Sugar hackberry | 88 | 68 | --- | --- | 225 | 174 | 217 | 172 | 660 | 541 | --- | --- | 198 | 159 |
| Mesquite | 621 | 656 | 128 | 136 | 885 | 944 | 908 | 961 | 256 | 274 | 419 | 1500 | 536 | 745 |
| Post oak | --- | --- | --- | --- | --- | --- | 219 | 220 | --- | --- | --- | --- | 37 | 37 |
| Live oak | 97 | 95 | 984 | 987 | 984 | 955 | 3094 | 3006 | 2023 | 1969 | --- | --- | 1197 | 1169 |
| Blackbrush | --- | --- | --- | --- | --- | --- | 61 | 56 | --- | --- | --- | --- | 10 | 9 |
| Baccharis | 98 | 74 | 139 | 94 | --- | --- | --- | --- | --- | --- | --- | --- | 40 | 28 |
| Sea oxeye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 104 | 106 | 17 | 18 |
| Granjeno | --- | --- | --- | --- | --- | --- | 179 | 235 | --- | --- | --- | --- | 30 | 39 |
| Macartney rose | 68 | 552 | 160 | 904 | 61 | 441 | --- | --- | 27 | 220 | --- | --- | 53 | 353 |
| Rattlepod | --- | --- | 15 | 15 | --- | --- | --- | --- | 6 | 6 | 15 | 16 | 6 | 6 |
| Greenbriar | 35 | 28 | --- | --- | --- | --- | --- | --- | 18 | 10 | --- | --- | 9 | 6 |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 239 | 233 | --- | --- | 40 | 39 |
| Big bluestem | 1 | 4 | t | t | 1 | 22 | 1 | t | 1 | 1 | --- | --- | 1 | 5 |
| Bushy bluestem | 7 | 6 | 7 | 6 | 9 | 6 | --- | --- | 17 | 10 | --- | --- | 7 | 5 |
| Silver bluestem | 9 | 20 | --- | --- | --- | --- | 7 | 8 | 3 | 3 | --- | --- | 3 | 5 |
| Sideoats grama | 4 | 13 | --- | --- | --- | --- | 18 | 4 | 7 | 6 | --- | --- | 5 | 4 |
| Panamerican balsamscale | - | --- | --- | --- | --- | --- | 41 | 13 | --- | --- | --- | --- | 7 | 2 |
| Switchgrass | 2 | 4 | 1 | 1 | 2 | 20 | --- | --- | 4 | 4 | --- | --- | 2 | 5 |
| Little bluestem | 36 | 80 | 33 | 32 | 167 | 446 | 235 | 57 | 10 | 8 | 1 | t | 80 | 104 |
| Plains bristlegrass | 4 | t | --- | --- | --- | --- | 20 | t | 11 | t | --- | --- | 6 | t |
| Indiangrass | 1 | 2 | 1 | 1 | 2 | 8 | 5 | 2 | 2 | 1 | --- | --- | 2 | 2 |
| Johnsongrass | 9 | t | --- | --- | 27 | t | --- | --- | 21 | t | --- | --- | 10 | t |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 545 | 345 | 91 | 58 |
| Smutgrass | 50 | 1 | 40 | 3 | 34 | 1 | --- | --- | --- | --- | --- | --- | 21 | 1 |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 17 | 12 | --- | --- | --- | --- | 3 | 2 |
| Purple threeawn | 7 | 149 | --- | --- | 2 | 2 | --- | --- | --- | --- | --- | --- | 2 | 25 |
| Buffalograss | 15 | 102 | --- | --- | --- | --- | 2 | 2 | 3 | 3 | 1 | t | 4 | 18 |
| Bermudagrass | 3 | 4 | 3 | 3 | 1 | 1 | 4 | 4 | 2 | 2 | 3 | 2 | 3 | 3 |
| Saltgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 29 | 1 | 5 | t |
| Longtom | 4 | t | 7 | 1 | 7 | 1 | --- | --- | 3 | t | --- | --- | 4 | t |
| Brownseed paspalum | 26 | t | 6 | t | 64 | 1 | 25 | t | 39 | t | --- | --- | 27 | t |
| Thin paspalum | 5 | 5 | 2 | 2 | 3 | 4 | 2 | 2 | --- | --- | --- | --- | 2 | 2 |
| Knotroot bristlegrass | 8 | 5 | 34 | 65 | 36 | 6 | 2 | 2 | 10 | 8 | --- | --- | 15 | 14 |
| Littletooth sedge | --- | --- | 25 | 86 | 1 | 1 | --- | --- | 125 | 12 | --- | --- | 25 | 17 |
| Flatsedge | 21 | 23 | 15 | 48 | --- | --- | --- | --- | 76 | 277 | --- | --- | 19 | 58 |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 44 | 27 | 7 | 5 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 6 | 5 | 80 | 7 | 14 | 2 |
| Ragweed | 11 | 31 | 9 | 18 | 15 | 36 | 173 | 315 | 337 | 468 | --- | --- | 91 | 145 |
| Wild indigo | 6 | 1 | 9 | 2 | 6 | 1 | --- | --- | 1 | t | --- | --- | 4 | 1 |
| Old-man’s beard | 16 | 2 | --- | --- | --- | --- | --- | --- | 163 | 7 | --- | --- | 30 | 2 |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 29 | 80 | 5 | 13 |
| Bush sunflower | 7 | 16 | --- | --- | 4 | 15 | 68 | 165 | --- | --- | --- | --- | 13 | 33 |

Dashes (---) indicate the species was not included in the simulation. A trace amount (<0.05 g/m$^2$) is indicated by “t”.

bottomland type. Little bluestem is a late-seral species on the sandy loam type and was able to replace the earlier-seral forbs over the 25-year simulation.

The brush control simulation did not include reseeding or a one- to two-year deferment of grazing following the application of the brush control. Both of these options would likely have increased the amount of midgrass biomass, especially the later-seral species, and would likely have decreased the amount of smutgrass.

The woody species began to recover during the 25 years of the simulation but not at the same rates among species or compared to the rates of increase without brush control. Two species that increased more rapidly than other woody species were sugar hackberry and Macartney rose. Averaged over the 25 years and over the six types, sugar hackberry biomass under the brush control scenario was 13% of its biomass without brush control (Table 9.14). Had sugar hackberry increased at the same successional rate as it did without brush control, it would have averaged 10% of the average amount without brush control. Likewise, Macartney rose biomass under the brush control scenario also averaged 13% of its value without brush control and averaged 15% on the loamy prairie type. By comparison, mesquite averaged 9% overall and huisache averaged 8% on the loamy prairie type compared to 15% for Macartney rose on the same type. This suggests that Macartney rose regrowth is likely to be more of an issue following rootplowing than either huisache or mesquite.

### 9.1.4.4 Removal (90%) of Woody Species, Dry and Wet Regimes

Altering the rainfall regime had little effect on biomass of trees. Trees had access to groundwater on most sites and this reduced the effect of annual variation in rainfall. Likewise, higher rainfall provided more moisture in the soil profile but the trees then shifted to use of more soil moisture and less groundwater. The exception was mesquite, which had higher biomass under the wet regime on all six types.

Moisture regime also had minimal effect on shrub and vine biomass, except for Macartney rose. Regrowth of Macartney rose following brush control was 11% greater under the wet regime than under the dry regime (Table 9.15). Macartney rose is best adapted to relatively wet conditions. In the western (drier) part of its range, it generally forms the thickest stands in swales and ditches. As annual rainfall increases, going from west to east, Macartney becomes common in relatively flat areas, but even in these cases it is often on soils that becomes saturated during periods of high rainfall.

Both midgrasses and shortgrasses increased under the wet regime, when averaged over each lifeform. Midgrass biomass increased by 17% under the wet regime, compared to the dry regime (Table 9.15). However, most of this increase came from smutgrass, which increased by 45% under the wet regime. Most other mid- and tallgrasses increased under the wet regime, but less so than smutgrass. In contrast, little bluestem decreased 6% under the wet regime and Johnsongrass also decreased. The reason smutgrass increased so much was because most of the other grasses were more highly preferred by cattle than was smutgrass. Although the overall stocking rate was calculated to be moderate, selection pressure was higher on the more preferred species, especially on the more abundant little bluestem. Consequently, smutgrass was grazed at

**Table 9.14 Effect of removal of 90% of woody plant biomass (50% of live oak) in March of Year 1 on aboveground biomass (g/m², end of growing season), by lifeform and by major species, on six vegetation types (38% initial woody plant cover) averaged over 25 years, Victoria County EDYS model, moderate rainfall regime. BC = removal, NO = no removal.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO | BC | NO |
| Trees | 197 | 2078 | 576 | 2534 | 676 | 2912 | 1771 | 4472 | 1234 | 3950 | 225 | 6259 | 780 | 3701 |
| Shrubs and vines | 70 | 654 | 135 | 1013 | 56 | 441 | 19 | 291 | 55 | 469 | 14 | 122 | 58 | 498 |
| Midgrasses | 680 | 132 | 589 | 45 | 721 | 503 | 386 | 85 | 92 | 34 | 396 | 345 | 478 | 191 |
| Shortgrasses | 109 | 266 | 155 | 72 | 84 | 16 | 45 | 23 | 50 | 14 | 16 | 3 | 76 | 66 |
| Grass-likes | 89 | 23 | 45 | 134 | 1 | 1 | --- | --- | 175 | 289 | 285 | 27 | 99 | 79 |
| Forbs | 44 | 53 | 29 | 21 | 34 | 52 | 251 | 480 | 523 | 480 | 134 | 87 | 169 | 196 |
| Total aboveground | 1189 | 3206 | 1529 | 3819 | 1572 | 3925 | 2472 | 5351 | 2129 | 5236 | 1070 | 6843 | 1660 | 4731 |
| Huisache | 83 | 1259 | 66 | 1411 | 67 | 839 | 12 | 113 | 23 | 227 | 153 | 4759 | 67 | 1435 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 95 | 939 | --- | --- | 16 | 157 |
| Sugar hackberry | 9 | 68 | --- | --- | 22 | 174 | 22 | 172 | 65 | 541 | --- | --- | 20 | 159 |
| Mesquite | 58 | 656 | 14 | 136 | 92 | 944 | 101 | 961 | 27 | 274 | 72 | 1500 | 61 | 745 |
| Post oak | --- | --- | --- | --- | --- | --- | 22 | 220 | --- | --- | --- | --- | 4 | 37 |
| Live oak | 47 | 95 | 496 | 987 | 495 | 955 | 1614 | 3006 | 1024 | 1969 | --- | --- | 613 | 1169 |
| Blackbrush | --- | --- | --- | --- | --- | --- | 6 | 56 | --- | --- | --- | --- | 1 | 9 |
| Baccharis | 8 | 74 | 10 | 94 | --- | --- | --- | --- | --- | --- | --- | --- | 3 | 28 |
| Sea oxeye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 12 | 106 | 2 | 18 |
| Granjeno | --- | --- | --- | --- | --- | --- | 13 | 235 | --- | --- | --- | --- | 2 | 39 |
| Macartney rose | 60 | 552 | 123 | 904 | 56 | 441 | --- | --- | 28 | 220 | --- | --- | 45 | 353 |
| Rattlepod | --- | --- | 2 | 15 | --- | --- | --- | --- | 1 | 6 | 2 | 16 | 1 | 6 |
| Greenbriar | 2 | 28 | --- | --- | --- | --- | --- | --- | 2 | 10 | --- | --- | 1 | 6 |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 24 | 233 | --- | --- | 4 | 39 |
| Big bluestem | 1 | 4 | t | t | 3 | 22 | 2 | t | 1 | 1 | --- | --- | 1 | 5 |
| Bushy bluestem | 7 | 6 | 9 | 6 | 10 | 6 | --- | --- | 32 | 10 | --- | --- | 10 | 5 |
| Silver bluestem | 8 | 20 | --- | --- | --- | --- | 7 | 8 | 3 | 3 | --- | --- | 3 | 5 |
| Sideoats grama | 2 | 13 | --- | --- | --- | --- | 29 | 4 | 7 | 6 | --- | --- | 6 | 4 |
| Panamerican balsamscale | - | --- | --- | --- | --- | --- | 46 | 13 | --- | --- | --- | --- | 8 | 2 |
| Switchgrass | 1 | 4 | 1 | 1 | 6 | 20 | --- | --- | 5 | 4 | --- | --- | 2 | 5 |
| Little bluestem | 24 | 80 | 38 | 32 | 306 | 446 | 274 | 57 | 12 | 8 | 1 | t | 109 | 104 |
| Plains bristlegrass | 6 | t | --- | --- | --- | --- | 19 | t | 16 | t | --- | --- | 7 | t |
| Indiangrass | 1 | 2 | 1 | 1 | 3 | 8 | 8 | 2 | 2 | 1 | --- | --- | 3 | 2 |
| Johnsongrass | 5 | t | --- | --- | 70 | t | --- | --- | 13 | t | --- | --- | 15 | t |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 395 | 345 | 66 | 58 |
| Smutgrass | 623 | 1 | 539 | 3 | 323 | 1 | --- | --- | --- | --- | --- | --- | 248 | 1 |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 17 | 12 | --- | --- | --- | --- | 3 | 2 |
| Purple threeawn | 9 | 149 | --- | --- | 2 | 2 | --- | --- | --- | --- | --- | --- | 2 | 25 |
| Buffalograss | 13 | 102 | --- | --- | --- | --- | 2 | 2 | 3 | 3 | t | t | 3 | 18 |
| Bermudagrass | 2 | 4 | 3 | 3 | 1 | 1 | 6 | 4 | 2 | 2 | 2 | 2 | 3 | 3 |
| Saltgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 14 | 1 | 2 | t |
| Longtom | 5 | t | 8 | 1 | 8 | 1 | --- | --- | 3 | t | --- | --- | 4 | t |
| Brownseed paspalum | 15 | t | 2 | t | 63 | 1 | 15 | t | 24 | t | --- | --- | 20 | t |
| Thin paspalum | 5 | 5 | 2 | 2 | 4 | 4 | 2 | 2 | --- | --- | --- | --- | 2 | 2 |
| Knotroot bristlegrass | 59 | 5 | 139 | 65 | 5 | 6 | 2 | 2 | 17 | 8 | --- | --- | 37 | 14 |
| Littletooth sedge | --- | --- | 2 | 86 | 1 | 1 | --- | --- | 12 | 12 | --- | --- | 3 | 17 |
| Flatsedge | 89 | 23 | 43 | 48 | --- | --- | --- | --- | 163 | 277 | --- | --- | 49 | 58 |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 285 | 27 | 48 | 5 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 6 | 5 | 3 | 7 | 2 | 2 |
| Ragweed | 17 | 31 | 20 | 18 | 24 | 36 | 187 | 315 | 308 | 468 | --- | --- | 93 | 145 |
| Wild indigo | 5 | 1 | 8 | 2 | 6 | 1 | --- | --- | 1 | t | --- | --- | 3 | 1 |
| Old-man's beard | 11 | 2 | --- | --- | --- | --- | --- | --- | 208 | 7 | --- | --- | 37 | 2 |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 131 | 80 | 22 | 13 |
| Bush sunflower | 9 | 16 | --- | --- | 4 | 4 | 63 | 165 | --- | --- | --- | --- | 13 | 33 |

Dashes (---) indicate the species was not included in the simulation. A trace amount (<0.05 g/m²) is indicated by "t".

a lighter level and therefore was able to compete more successfully against the other grasses. In a study conducted in northwest Calhoun County, cattle consumed substantial amounts of smutgrass during winter months when smutgrass retained some green leaves, but quickly shifted to other grasses, such as little bluestem, when these species began growth in early spring (Durham and Kothmann 1977). Little bluestem, sideoats grama, and big bluestem all increased substantially under the wet regime on the sandy loam type where smutgrass was not included. Gulf cordgrass decreased on the salty bottomland type under the wet regime because of a corresponding increase in Olney bulrush, resulting from the sites becoming much wetter.

Of the shortgrasses, two species dominated the dynamics in this lifeform in relation to rainfall regime. Brownseed paspalum decreased 22% under the wet regime compared to the dry regime and knotroot bristlegrass increased 29% (Table 9.15). These responses were also the result of differential grazing by cattle. Brownseed paspalum is a preferred species and knotroot bristlegrass has low preference by cattle, in some cases not being selected at all if other grasses are available (Durham and Kothmann 1977). In the wet regime simulation, knotroot bristlegrass comprised over 9% of total herbaceous biomass averaged over the six types and 14% on the claypan prairie type and 19% on the loamy bottomland type. These levels of abundance of knotroot bristlegrass are common on heavily grazed coastal prairie ranges (Durham and Kothmann 1977; McLendon and Dahl 1983).

**Table 9.15 Effect of removal of 90% of woody plant biomass (50% of live oak) in March of Year 1 on aboveground biomass ($g/m^2$, end of growing season), by lifeform and by major species, on six vegetation types (38% initial woody plant cover) averaged over 25 years , Victoria County EDYS model, dry and wet rainfall regimes. DR = dry regime, WT = wet regime.**

| Lifeform/Species | Blackland | | Claypan Prairie | | Loamy Prairie | | Sandy Loam | | Loamy Bottomland | | Salty Bottomland | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DR | WT | DR | WT | DR | WT | DR | WT | DR | WT | DR | WT | DR | WT |
| Trees | 196 | 203 | 581 | 584 | 675 | 669 | 1807 | 1761 | 1217 | 1242 | 202 | 225 | 780 | 781 |
| Shrubs and vines | 70 | 83 | 132 | 147 | 55 | 58 | 19 | 20 | 54 | 61 | 14 | 15 | 57 | 64 |
| Midgrasses | 377 | 489 | 504 | 619 | 630 | 729 | 372 | 517 | 80 | 78 | 466 | 402 | 405 | 472 |
| Shortgrasses | 158 | 169 | 142 | 132 | 95 | 136 | 54 | 69 | 189 | 208 | 17 | 21 | 109 | 122 |
| Grass-likes | 53 | 64 | 37 | 50 | 1 | 1 | --- | --- | 124 | 166 | 241 | 331 | 76 | 102 |
| Forbs | 41 | 41 | 30 | 26 | 33 | 29 | 168 | 118 | 431 | 385 | 94 | 83 | 133 | 114 |
| Total aboveground | 895 | 1049 | 1426 | 1558 | 1489 | 1622 | 2420 | 2485 | 2095 | 2140 | 1034 | 1077 | 1560 | 1655 |
| Huisache | 85 | 85 | 69 | 69 | 66 | 66 | 12 | 12 | 23 | 22 | 142 | 145 | 66 | 67 |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 95 | 97 | --- | --- | 16 | 16 |
| Sugar hackberry | 9 | 9 | --- | --- | 22 | 22 | 22 | 22 | 65 | 66 | --- | --- | 20 | 20 |
| Mesquite | 55 | 61 | 13 | 14 | 81 | 85 | 96 | 98 | 26 | 28 | 60 | 80 | 55 | 61 |
| Post oak | --- | --- | --- | --- | --- | --- | 22 | 22 | --- | --- | --- | --- | 4 | 4 |
| Live oak | 47 | 48 | 499 | 501 | 506 | 496 | 1655 | 1607 | 1008 | 1029 | --- | --- | 619 | 614 |
| Baccharis | 8 | 8 | 9 | 9 | --- | --- | --- | --- | --- | --- | --- | --- | 3 | 3 |
| Sea oxeye | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 12 | 13 | 2 | 2 |
| Granjeno | --- | --- | --- | --- | --- | --- | 13 | 14 | --- | --- | --- | --- | 2 | 2 |
| Macartney rose | 60 | 73 | 121 | 136 | 55 | 58 | --- | --- | 27 | 32 | --- | --- | 44 | 50 |
| Mustang grape | --- | --- | --- | --- | --- | --- | --- | --- | 24 | 26 | --- | --- | 4 | 4 |
| Big bluestem | 1 | 1 | 1 | 1 | 3 | 2 | 3 | 11 | 1 | 1 | --- | --- | 2 | 3 |
| Bushy bluestem | 7 | 8 | 9 | 13 | 9 | 9 | --- | --- | 11 | 8 | --- | --- | 6 | 6 |
| Silver bluestem | 9 | 10 | --- | --- | --- | --- | 8 | 8 | 3 | 3 | --- | --- | 3 | 4 |
| Sideoats grama | 3 | 3 | --- | --- | --- | --- | 25 | 71 | 6 | 6 | --- | --- | 6 | 13 |
| Panamerican balsamscale | - | --- | --- | --- | --- | --- | 30 | 31 | --- | --- | --- | --- | 5 | 5 |
| Switchgrass | 2 | 2 | 1 | 1 | 4 | 2 | --- | --- | 4 | 5 | --- | --- | 2 | 2 |
| Little bluestem | 38 | 34 | 54 | 40 | 241 | 134 | 276 | 364 | 11 | 12 | 1 | 1 | 104 | 98 |
| Plains bristlegrass | 8 | 8 | --- | --- | --- | --- | 23 | 23 | 21 | 22 | --- | --- | 9 | 9 |
| Indiangrass | 2 | 1 | 2 | 1 | 3 | 2 | 6 | 7 | 2 | 2 | --- | --- | 3 | 2 |
| Johnsongrass | 7 | 6 | --- | --- | 41 | 14 | --- | --- | 19 | 18 | --- | --- | 11 | 6 |
| Gulf cordgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 465 | 401 | 78 | 67 |
| Tall dropseed | 2 | 2 | 1 | 1 | --- | --- | 1 | 1 | --- | --- | --- | --- | 1 | 1 |
| Smutgrass | 297 | 413 | 436 | 562 | 329 | 566 | --- | --- | --- | --- | --- | --- | 177 | 257 |
| Arrowfeather threeawn | --- | --- | --- | --- | --- | --- | 14 | 15 | --- | --- | --- | --- | 2 | 3 |
| Purple threeawn | 8 | 7 | --- | --- | 2 | 2 | --- | --- | --- | --- | --- | --- | 2 | 2 |
| Buffalograss | 17 | 17 | --- | --- | --- | --- | 2 | 2 | 3 | 3 | t | 1 | 4 | 4 |
| Bermudagrass | 3 | 3 | 3 | 3 | 1 | 1 | 5 | 6 | 2 | 2 | 2 | 3 | 3 | 3 |
| Saltgrass | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 15 | 17 | 3 | 3 |
| Longtom | 5 | 5 | 9 | 8 | 8 | 8 | --- | --- | 3 | 3 | --- | --- | 4 | 4 |
| Brownseed paspalum | 20 | 17 | 2 | 2 | 58 | 29 | 27 | 38 | 29 | 23 | --- | --- | 23 | 18 |
| Thin paspalum | 4 | 5 | 2 | 2 | 3 | 4 | 2 | 2 | --- | --- | --- | --- | 2 | 2 |
| Knotroot bristlegrass | 73 | 87 | 125 | 116 | 21 | 89 | 2 | 4 | 126 | 155 | --- | --- | 58 | 75 |
| Texas wintergrass | 28 | 28 | --- | --- | 2 | 3 | 2 | 2 | 26 | 22 | --- | --- | 10 | 9 |
| Littletooth sedge | --- | --- | 2 | 2 | 1 | 1 | --- | --- | 17 | 19 | --- | --- | 3 | 4 |
| Flatsedge | 53 | 64 | 35 | 48 | --- | --- | --- | --- | 107 | 147 | --- | --- | 33 | 43 |
| Olney bulrush | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 241 | 331 | 40 | 55 |
| Spiny aster | --- | --- | --- | --- | --- | --- | --- | --- | 2 | 3 | 3 | 5 | 1 | 1 |
| Ragweed | 12 | 12 | 21 | 17 | 22 | 18 | 136 | 109 | 368 | 312 | --- | --- | 93 | 78 |
| Wild indigo | 6 | 6 | 8 | 8 | 6 | 5 | --- | --- | 1 | 1 | --- | --- | 4 | 3 |
| Old-man's beard | 15 | 15 | --- | --- | --- | --- | --- | --- | 60 | 69 | --- | --- | 13 | 14 |
| Glasswort | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 91 | 78 | 15 | 13 |
| Bush sunflower | 6 | 6 | --- | --- | 4 | 5 | 31 | 18 | --- | --- | --- | --- | 7 | 5 |

Dashes (---) indicate the species was not included in the simulation. A trace amount (<0.05 $g/m^2$) is indicated by "t".

## 9.2 Ecohydrology

### 9.2.1 Water Balance: Average Rainfall

Rainfall averaged 38.38 inches per year over the 25-year simulation under the average rainfall regime (Table 9.16). The difference in this amount from the 36.82 inches in the stated average rainfall scenario (Section 9.0) was the result of spatial variability across the County (Section 4.2). An average of 2.8% of annual rainfall left the landscape as surface runoff. This compares to 2.6% averaged over two range types (clay and loamy sand) from gauged watersheds in San Patricio County (Ockerman 2002). Evapotranspiration (ET) was 42% more than rainfall when averaged over the 25 years, or 37% more using the overall averages (Table 9.16). This high ET rate compared to annual rainfall was possible because of a relatively high amount of groundwater use by the vegetation and by extraction of stored soil moisture. Groundwater use equaled almost 27% of annual rainfall, 19% of total ET, and 71% of the amount that ET exceeded rainfall. The high level of groundwater-use in the simulation (19% of ET) is similar to levels documented in field studies in other plant communities with shallow groundwater. Mesquite woodlands in Arizona where groundwater was at a depth of 10 m (33 ft) utilized 30% groundwater (Snyder and Williams (2003) and Ashe juniper woodlands in the Edwards Plateau may utilize as much as 25% groundwater (Jackson et al. 2000).

**Table 9.16 Annual fluctuations in simulated hydrologic variables averaged over the entire Victoria County under the baseline (average rainfall regime) conditions.**

| Year | Rainfall (inches) | Rainfall (ac-ft) | Runoff (ac-ft) | Runoff/ Rainfall | ET (ac-ft) | ET/ Rainfall | GW Use (ac-ft) | GW Use/ ET | Net Soil Storage (ac-ft) |
|---|---|---|---|---|---|---|---|---|---|
| 01 | 25.89 | 1,227,554 | 6,969 | 0.006 | 2,126,723 | 1.732 | 576,093 | 0.271 | - 330,045 |
| 02 | 22.05 | 1,045,483 | 7,760 | 0.007 | 2,038,961 | 1.950 | 559,881 | 0.275 | - 441,357 |
| 03 | 33.30 | 1,578,893 | 38,152 | 0.024 | 2,597,213 | 1.645 | 580,057 | 0.223 | - 476,415 |
| 04 | 30.85 | 1,462,729 | 16,230 | 0.011 | 2,546,493 | 1.741 | 686,060 | 0.269 | - 413,934 |
| 05 | 35.44 | 1,680,360 | 43,649 | 0.026 | 2,813,786 | 1.675 | 582,223 | 0.207 | - 594,852 |
| 06 | 33.88 | 1,606,394 | 91,715 | 0.057 | 2,376,399 | 1.479 | 605,482 | 0.255 | - 256,238 |
| 07 | 49.29 | 2,337,047 | 71,522 | 0.031 | 2,942,275 | 1.259 | 471,117 | 0.160 | - 205,633 |
| 08 | 44.61 | 2,115,148 | 80,819 | 0.038 | 2,739,696 | 1.295 | 507,991 | 0.185 | - 197,376 |
| 09 | 39.76 | 1,885,189 | 61,908 | 0.033 | 2,774,495 | 1.472 | 472,044 | 0.170 | - 479,170 |
| 10 | 36.04 | 1,708,808 | 52,190 | 0.031 | 2,424,864 | 1.419 | 539,814 | 0.223 | - 228,432 |
| 11 | 42.14 | 1,998,035 | 78,178 | 0.039 | 2,721,146 | 1.362 | 458,456 | 0.168 | - 342,833 |
| 12 | 45.62 | 2,163,037 | 51,414 | 0.024 | 2,778,014 | 1.284 | 453,072 | 0.163 | - 213,319 |
| 13 | 43.32 | 2,053,984 | 50,267 | 0.024 | 2,662,161 | 1.296 | 459,569 | 0.173 | - 198,875 |
| 14 | 36.95 | 1,751,955 | 64,261 | 0.037 | 2,510,102 | 1.433 | 463,011 | 0.184 | - 359,397 |
| 15 | 43.25 | 2,050,665 | 9,297 | 0.005 | 2,672,702 | 1.303 | 465,762 | 0.174 | - 165,572 |
| 16 | 39.19 | 1,858,163 | 88,756 | 0.048 | 2,517,199 | 1.355 | 432,736 | 0.172 | - 315,056 |
| 17 | 43.04 | 2,040,708 | 106,753 | 0.052 | 2,469,514 | 1.210 | 451,524 | 0.183 | - 84,035 |
| 18 | 49.28 | 2,336,573 | 64,684 | 0.028 | 2,797,002 | 1.197 | 367,404 | 0.131 | - 157,709 |
| 19 | 32.52 | 1,541,910 | 39,848 | 0.026 | 2,270,540 | 1.473 | 439,553 | 0.194 | - 328,925 |
| 20 | 45.07 | 2,136,959 | 65,789 | 0.031 | 2,616,374 | 1.224 | 373,092 | 0.143 | - 172,112 |
| 21 | 32.49 | 1,540,488 | 84,633 | 0.055 | 2,013,577 | 1.307 | 440,690 | 0.219 | - 117,032 |
| 22 | 42.38 | 2,009,414 | 48,084 | 0.024 | 2,550,937 | 1.269 | 399,333 | 0.157 | - 190,274 |
| 23 | 33.92 | 1,608,290 | 12,105 | 0.008 | 2,286,998 | 1.422 | 448,267 | 0.196 | - 242,546 |
| 24 | 39.96 | 1,894,672 | 55,491 | 0.029 | 2,434,926 | 1.285 | 386,872 | 0.159 | - 208,873 |
| 25 | 39.17 | 1,857,215 | 17,662 | 0.010 | 2,444,676 | 1.316 | 438,074 | 0.179 | - 167,049 |
| Mean | 38.38 | 1,819,587 | 52,325 | 0.028 | 2,525,071 | 1.416 | 482,327 | 0.193 | - 275,482 |

Rainfall Year is the year from which the annual rainfall data were taken.
ET = evapotranspiration. GW Use = groundwater used by vegetation in transpiration (included as part of ET).
Net Soil Storage = Rainfall + GW Use – ET - Runoff.

The remaining amount of ET in excess of rainfall came from extraction of stored soil moisture. On average, there was an annual deficit of 275,482 acre-feet of soil moisture per year (Table 9.16). EDYS begins a simulation with a specified amount of soil moisture in each soil layer. This amount can be set at any level but is commonly set at 50% of field capacity for each layer. The amount of water corresponding to this level of soil moisture in each soil layer is available to plants for those layers within the rooting zone of each particular species. In this baseline scenario for the Victoria County model, there was soil moisture recharge in only 1 of the 25 years (Table 9.16). Both the direction and magnitude of this annual dynamic are dependent on a number of factors, including amount of rainfall, when the rainfall occurred, and vegetation composition and production.

In the baseline simulation, there was a net deficit over the 25 years and a deficit cannot be continued indefinitely. Over a sufficiently long period, soil moisture would eventually be depleted and vegetation would adjust to a level and composition that could be supported by rainfall and groundwater only. The 275,482 acre-feet of annual deficit simulated in the baseline scenario for the entire County equals an average of 5.8 inches of soil water per year. At a 15% average field capacity (Miller 1982, Table 15), this equals to a dewatering rate of 38-39 inches per year. In 3-4 years, this rate would effectively dewater the rooting zone of most grasses and therefore make them dependent on annual rainfall alone in most years. Deeper rooted woody species would continue to have access to deeper soil moisture for several decades longer and on groundwater as long as the water table did not decrease substantially.

Over time however, even while deeper moisture remained available to woody species, their extraction of that deep-moisture would decrease because of reduced efficiency of extraction as depth increased. That reduction was evident in the simulation results. During the first ten years of the simulation, net soil storage decreased by an average of 362,345 acre-feet per year but decreased by an average of only 198,361 acre-feet per year in the last ten years of the simulation (Table 9.16), a decrease in average annual soil moisture extraction of 45%. At a dewatering rate of 38-39 inches per year, the depth of available soil moisture (independent of groundwater) would be an average of about 32 feet deeper during the last ten years of the simulation than during the first ten years. Mesquite woodland in Arizona had 25% less ET at a 33-ft depth to groundwater than at a 6-ft depth (Scott et al. 2000, 2006).

Annual rainfall varied between 22.05 and 49.29 inches in the simulation and this variation resulted in substantial hydrologic variability (Table 9.16). Runoff was less than 8,000 acre-feet county-wide in two years and more than 80,000 acre-feet in five years. ET varied from about 2 million acre-feet to almost 3 million acre-feet and from 120% to 195% of annual rainfall. Groundwater use by vegetation varied between 367,000 acre-feet and 686,000 acre-feet per year.

### 9.2.2 Effects of Management Scenarios

#### 9.2.2.1 Runoff

Runoff varied by year (Table 9.16) and under the different scenarios (Table 9.17). Annual variation resulted in large part because of 1) changes in amount of rainfall, 2) timing of the rainfall, and 3) changes in vegetation.

**Table 9.17 Annual rainfall (inches) and annual runoff (acre-feet) averaged over all Victoria County under various 15- and 25-year EDYS scenario simulations.**

| Scenario | Annual Runoff (ac-ft) | | Runoff/Acre/Yr (inches) | | Annual Rainfall (inches) | | Runoff/Rainfall | |
|---|---|---|---|---|---|---|---|---|
| | 15 yrs | 25 yrs | 15 yrs | 25 yrs | 15 yrs | 25 yrs | 15 yrs | 25 yrs |
| Baseline | 48,289 | 52,325 | 1.02 | 1.10 | 37.49 | 38.38 | 0.027 | 0.029 |
| Dry Regime | 37,985 | 32,191 | 0.80 | 0.68 | 35.58 | 32.09 | 0.022 | 0.021 |
| Wet Regime | 58,731 | 59,236 | 1.24 | 1.25 | 41.63 | 42.98 | 0.030 | 0.029 |
| Moderate Cattle Grazing | 51,320 | 55,073 | 1.08 | 1.16 | 37.49 | 38.38 | 0.029 | 0.030 |
| Heavy Cattle Grazing | 50,939 | 54,632 | 1.07 | 1.15 | 37.49 | 38.38 | 0.029 | 0.030 |
| Brush Control | | | | | | | | |
| 90% Huisache; Ave PPT | 50,616 | 54,803 | 1.07 | 1.16 | 37.49 | 38.38 | 0.029 | 0.030 |
| 90% Macartney rose; Ave PPT | 48,929 | 53,075 | 1.03 | 1.12 | 37.49 | 38.38 | 0.028 | 0.029 |
| 90% Woody (50% Oak); Ave PPT | 52,015 | 57,090 | 1.10 | 1.20 | 37.49 | 38.38 | 0.029 | 0.031 |
| 90% Woody (50% Oak); Dry PPT | 40,227 | 34,124 | 0.85 | 0.72 | 35.58 | 32.09 | 0.024 | 0.022 |
| 90% Woody (50% Oak); Wet PPT | 61,352 | 63,105 | 1.29 | 1.33 | 41.63 | 42.98 | 0.031 | 0.031 |

Baseline, Dry Regime, and Wet Regime scenarios are with no cattle grazing.
Brush Control scenarios include 90% removal of target woody species except live oak and a moderate stocking rate of cattle. The amount of live oak removed is either 0% or 50%.
Average annual rainfall amounts in Table 9.17 do not equal those listed for the scenarios because of spatial variation over the County.

Runoff decreased in drier years and increased in wetter years (Table 9.17). On average over a 25-year period, runoff in dry years (average rainfall = 32 inches) decreased by 38% compared to runoff in moderate-rainfall years when rainfall averaged 20% more (mean = 38 inches). Runoff in wet years averaged 13% more than runoff in moderate-rainfall years, which was about equal to the increase in rainfall (12%). By comparison, a 43% increase in annual rainfall resulted in a 57% increase in runoff on cultivated clay sites in Kleberg and Nueces Counties (Ockerman and Petri 2001). When averaged over 15 years, annual runoff was lower than when averaged over 25 years under the moderate (baseline) regime, higher under the dry regime, and about equal under the wet regime. These differences were the result of differences in annual rainfall during the first 15 years compared to the last 10 years. For example, the last 10 years of the dry regime included the drought years of the 1950s which were the driest years on record.

Although runoff increased as annual rainfall increased in the simulations, the increases were not linear. On average in the Victoria model simulations (Table 9.18), one inch of annual rainfall resulted in 651 acre-feet of runoff in dry years (< 31.3 inches), 1,244 acre-feet in moderate-rainfall years, and 1,565 acre-feet in wet years.

**Table 9.18 Annual runoff (acre-feet, county-wide), annual rainfall (inches), and previous-year rainfall (inches) in EDYS simulations for dry, moderate, and high rainfall years, Victoria County EDYS model. All 75 years from the three simulations (dry, moderate, wet regimes) are included.**

| | Dry Years (< 31.3 inches) | | | Moderate (31.3-42.5 inches) | | | Wet Years (> 42.5 inches) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Rainfall | Annual Runoff | Previous Rainfall | Annual Rainfall | Annual Runoff | Previous Rainfall | Annual Rainfall | Annual Runoff | Previous Rainfall |
| | 14.32 | 2,658 | 30.33 | 32.24 | 62,886 | 25.51 | 42.67 | 78,993 | 64.99 |
| | 16.16 | 2,007 | 43.08 | 32.49 | 84,633 | 45.07 | 43.04 | 106,753 | 39.19 |
| | 18.65 | 11,188 | 35.12 | 32.52 | 39,848 | 49.28 | 43.08 | 33,928 | 39.17 |
| | 19.89 | 10,096 | 22.49 | 33.30 | 38,152 | 22.05 | 43.16 | 58,390 | 54.82 |
| | 20.57 | 20,218 | 32.24 | 33.88 | 91,715 | 35.44 | 43.25 | 9,297 | 36.95 |
| | 22.05 | 7,760 | 25.89 | 33.92 | 12,105 | 42.38 | 43.32 | 50,267 | 45.62 |
| | 22.49 | 10,645 | 34.45 | 33.92 | 12,337 | 42.38 | 43.46 | 51,502 | 37.54 |
| | 23.73 | 28,713 | 29.30 | 34.45 | 33,982 | 27.04 | 44.61 | 80,819 | 49.29 |
| | 25.51 | 17,505 | 46.67 | 34.93 | 13,064 | 73.51 | 45.07 | 65,789 | 32.53 |
| | 25.89 | 6,969 | ----- | 35.12 | 11,489 | 19.89 | 45.62 | 51,414 | 42.14 |
| | 26.25 | 24,330 | 16.16 | 35.16 | 30,134 | 30.32 | 46.67 | 64,614 | 37.28 |
| | 27.04 | 18,495 | 43.46 | 35.44 | 43,469 | 30.85 | 49.28 | 64,684 | 43.04 |
| | 27.70 | 19,701 | 37.67 | 35.65 | 35,934 | 20.57 | 49.29 | 71,522 | 33.88 |
| | 29.30 | 28,250 | 37.15 | 36.04 | 52,190 | 39.76 | 51.00 | 45,045 | 35.65 |
| | 30.32 | 27,564 | ----- | 36.65 | 22,831 | 30.36 | 54.82 | 102,650 | 58.40 |
| | 30.33 | 12,965 | 23.73 | 36.78 | 74,002 | 26.25 | 58.40 | 114,570 | 60.07 |
| | 30.36 | 21,838 | 42.67 | 36.95 | 64,261 | 43.32 | 60.07 | 153,221 | 36.78 |
| | 30.85 | 16,230 | 33.30 | 37.15 | 37,712 | 37.44 | 64.99 | 148,921 | 27.70 |
| | | | | 37.28 | 15,504 | 38.54 | 71.73 | 103,292 | 39.41 |
| | | | | 37.44 | 81,279 | 18.65 | 73.51 | 136,528 | 37.57 |
| | | | | 37.54 | 26,859 | 38.32 | | | |
| | | | | 37.57 | 27,316 | 41.10 | | | |
| | | | | 37.67 | 20,233 | 43.16 | | | |
| | | | | 38.32 | 54,283 | 51.00 | | | |
| | | | | 38.54 | 65,248 | 35.16 | | | |
| | | | | 39.17 | 17,662 | 39.96 | | | |
| | | | | 39.17 | 17,970 | 39.96 | | | |
| | | | | 39.19 | 88,756 | 43.25 | | | |
| | | | | 39.41 | 54,262 | 34.93 | | | |
| | | | | 39.76 | 61,908 | 44.61 | | | |
| | | | | 39.96 | 55,491 | 33.92 | | | |
| | | | | 39.96 | 58,358 | 33.92 | | | |
| | | | | 41.10 | 75,717 | 41.98 | | | |
| | | | | 41.98 | 66,087 | 36.65 | | | |
| | | | | 42.14 | 78,178 | 36.04 | | | |
| | | | | 42.38 | 48,084 | 32.49 | | | |
| | | | | 42.38 | 40,340 | ----- | | | |
| Mean | 24.52 | 15,952 | 33.36 | 37.23 | 46,332 | 36.81 | 50.85 | 79,610 | 42.60 |

Dry year = < 85% of annual mean, moderate year = 85-115% of annual mean, wet year = > 115% of annual mean.
Mean annual rainfall 1898-2015 = 36.91 inches.
Dashes (-----) indicate first year of a simulation (no previous-year data).
Four duplicate years are included, but under different scenarios (moderate or wet).

In addition to the non-linear relationship between runoff and average annual rainfall, there was high variation among years, especially in years with moderate rainfall (Fig. 9.2). The four lowest runoff years occurred in the dry rainfall group (Table 9.18), as would be expected, but a relatively low runoff year also occurred under high rainfall (43 inches). All dry years had simulated annual runoff of less than 30,000 acre-feet, but 11 moderate-rainfall years (30%) also had less than 30,000 acre-feet of runoff. It was common in all three groups (dry, moderate, wet) for years with about the same amount of rainfall (less than 0.5-inch difference) to have simulated runoff that differed by a factor of 2-3. This among-year variability in runoff was not likely to have been the result of antecedent rainfall because there was no consistent relationship among amount of runoff, previous-year rainfall, and annual rainfall.

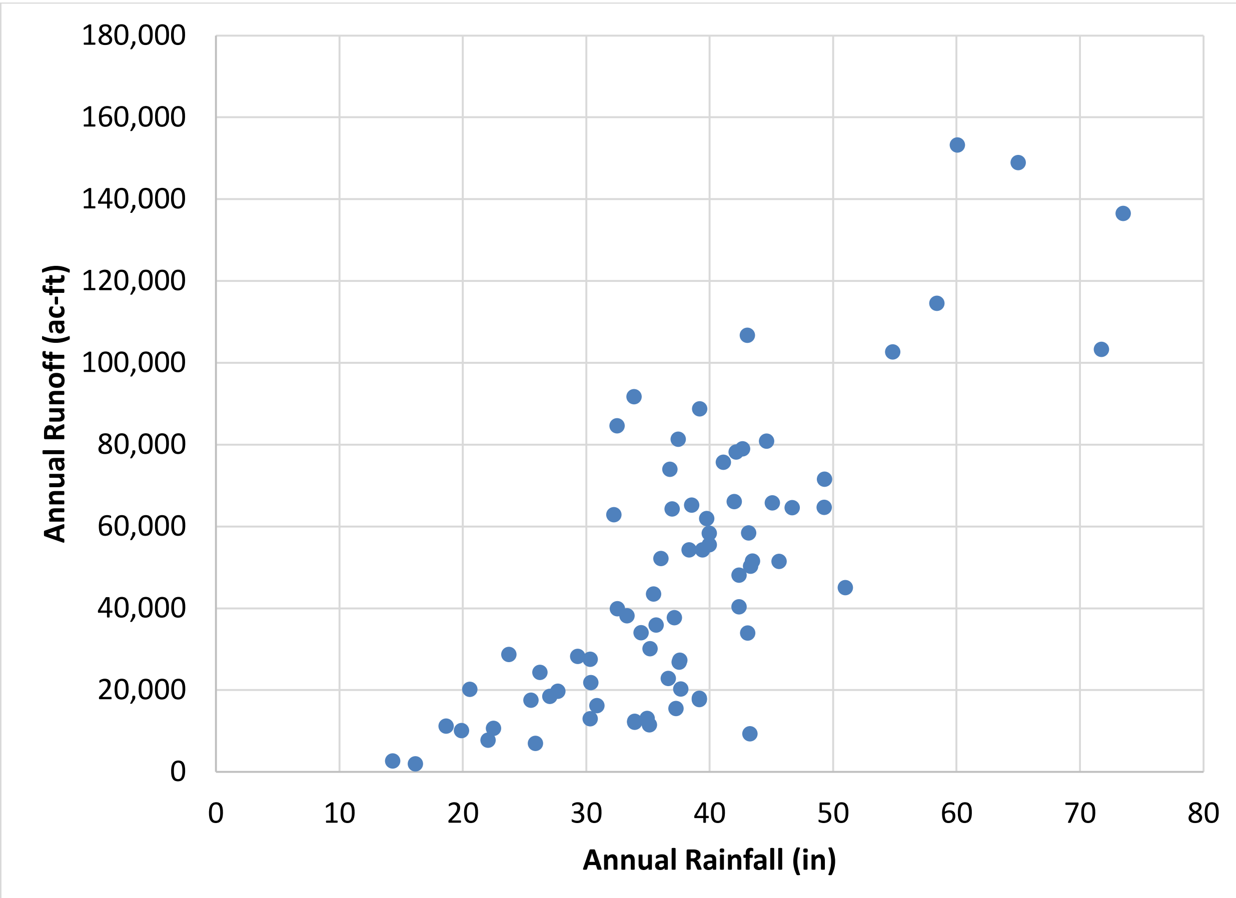


**Figure 9.2 Relationship between surface runoff (y-axis) and annual rainfall (x-axis) in Victoria County, based on combined results of the dry-, moderate-, and wet-rainfall 25-year EDYS scenarios (data from Table 9.18).**

The factors that most likely affected runoff on an annual basis were timing of the rainfall and vegetation condition at the time of rainfall. For example, annual rainfall was similar in Years 12 (1943 = 37.54 inches) and 20 (1951 = 37.44 inches) of the dry scenario, but annual runoff in Year 12 was 26,859 acre-feet compared to 81,279 acre-feet in Year 20. Monthly rainfall in 1943 was less than 6.5 inches. In 1951, nearly 7.5 inches was received in May and 8.5 inches was received in September. In addition, the heavier May and September rainfall in 1951 fell on dry ground, the previous months having received 0.5-inch or less. Vegetation cover in 1951 was low because of the beginning of the drought of the 1950s. Therefore, Year 20 received high rainfall in two months and had low herbaceous cover, resulting in high runoff. Rainfall in 1943 was more uniform and herbaceous cover was higher because the three previous years received above average rainfall. Consequently, runoff in Year 12 was less.

Under the dry scenario, annual runoff decreased by 38% compared to runoff under the moderate regime, averaged over 25 years. Average annual rainfall under the dry regime was 16% less than under the moderate regime. This 2.4 response ratio to decreased rainfall over a 25-year period (38% decrease in runoff/16% decrease in rainfall = 2.4) is similar to the ratio indicated in the dry vs. moderate years of the three simulations (67%/34% = 2.0; Table 9.18) and very near the 2.5 response ratio from a two-year gauged study on central Texas Coast rangeland (Ockerman 2002). Based on these ratios, surface runoff may be expected to decrease at a rate (% basis) equal to twice that of the decrease in rainfall.

During the 20 wet years of the simulations (Table 9.18), annual runoff averaged 72% more than under the 37 moderate-rainfall years but average annual rainfall was only 16% more in the wet years. This equals a 4.5 response ratio (72% increase in runoff/16% increase in rainfall). The higher response ratio under the wet scenario (compared to moderate) than under the dry scenario (compared to moderate) was because there were more extreme (high rainfall) events in the wet scenario. As rainfall increases, runoff also increases but at a higher rate. Under rangeland conditions on the central Texas Coast for example, rainfall events of more than 4 inches produced six times as much surface runoff as moderate events of 1.9-2.6 inches (Ockerman 2002).

Cattle grazing increased surface runoff (Table 9.17). Under moderate stocking rates, runoff increased by 6% when averaged over 15 years and by 5% averaged over 25 years, compared to no grazing under the moderate rainfall regime. The heavy stocking rate decreased runoff slightly when compared to the moderate stocking rate, but was still higher than without grazing. The increased runoff with grazing was the result of lower total aboveground biomass under grazed conditions (Table 9.10). Some vegetation types had higher grass biomass when moderately grazed but other types had substantially less grass biomass. Higher grass biomass results in lower surface runoff, while lower grass biomass results in higher runoff. Heavy grazing resulted in a vegetation response intermediate between the moderate stocking rate and no grazing, which resulted in the intermediate runoff values. In the Edwards Plateau, a high-intensity grazing system resulted in a 43% increase in surface runoff compared to a moderate-intensity grazing system (Thurow et al. 1988).

Brush control had only a modest impact on surface runoff (Table 9.17). Although total aboveground biomass was reduced by brush control, with a resulting increase in runoff, grass biomass increased substantially following brush control and this decreased runoff. The net effect was that under the moderate rainfall scenario and with a moderate cattle stocking rate runoff increased by 700 acre-feet per year (1%) when averaged over 15 years and 2,000 acre-feet per year (4%) when averaged over 25 years. Under the dry rainfall regime, runoff averaged 11,800 acre-feet per year less averaged over 15 years (22,900 acre-feet per year less over 25 years) than under the moderate regime following brush control under both regimes. This was 1,500 acre-feet more per year (15-year average) than without brush control when comparing dry to moderate rainfall conditions. Under the wet regime, runoff following brush control was 18% higher than under the moderate regime averaged over 15 years and 11% higher averaged over 25 years.

Removal of only huisache or only Macartney rose resulted in less surface runoff than without removal of these two species, under the moderate rainfall regime and with a moderate cattle stocking rate (Table 9.17). In the case of huisache removal, the decrease in runoff was the result of a substantial increase in grass biomass with little corresponding increase in other woody species (Table 9.12). In the case of Macartney rose it was the result of huisache replacing Macartney rose, with a net increase in woody species on some types, and only a modest increase in grasses (Table 9.13).

#### 9.2.2.2 Evapotranspiration

Evapotranspiration (ET) averaged 2.5 million acre-feet per year for the county as a whole over the 25-year baseline simulation (moderate rainfall regime, no livestock grazing) and an annual average of about 2,540,000 acre-feet when averaged over the first 15 years (Table 9.16). These were equal to about 52.7 inches per year, or about 142% of annual rainfall (149% of annual rainfall over the first 15 years of the simulation), but varied from year to year. What allowed ET to exceed rainfall by such a large amount was the substantial use of groundwater by the vegetation. On average, under baseline conditions, the vegetation utilized over 482,000 acre-feet of groundwater annually, which was 19% of total ET (Table 9.16).

Combining data from all 75 years of the three simulations (dry, moderate, wet) without grazing or brush control, rainfall had a substantial effect on ET (Table 9.19). In dry years (less than 85% of annual mean, or less than 31.3 inches; mean = 24.5 inches), ET averaged 2,246,445 acre-feet and generally increased as rainfall increased, from a low of 1,847,000 acre-feet when annual rainfall was 14.3 inches to 2,546,000 acre-feet when rainfall was 30.9 inches. In years with moderate rainfall (31.3-42.5 inches; mean = 37.2 inches), ET averaged 2,530,000 acre-feet. There was substantial variability in annual ET in moderate rainfall years, varying between 2,013,000 and 3,078,000 acre-feet, but the variability was not as strongly linked to annual rainfall variability as it was in dry years. In wet years (more than 42.5 inches; mean = 50.9 inches), ET averaged 2,886,000 acre-feet and varied between 2,470,000 and 3,219,000 acre-feet per year.

When groundwater is too deep for any significant use by vegetation, vegetation is dependent on precipitation, both current-year and stored soil moisture unused from previous years. This effectively limits maximum ET to an average of about 1.00 of annual precipitation when averaged over several years. Annual ET can exceed annual precipitation is some years because of use of stored moisture. For example, ET in a mesquite-granjeno shrubland in South Texas was 1.06 of annual rainfall in a dry year (13.0 inches ET) compared to 0.99 in a wet year (ET = 34.6 inches)(Weltz and Blackburn 1995). In the Rolling Plains of Texas, the annual ET:rainfall ratio varied over a three-year study period between 0.81 and 1.12 on a mesquite-grassland site and between 0.86 and 1.19 on an adjacent grassland site (Carlson et al. 1990).

**Table 9.19 Annual rainfall (inches), annual evapotranspiration (ET; acre-feet, county-wide), and ratio of ET:rainfall in EDYS simulations for dry, moderate, and high rainfall years, Victoria County EDYS model, with no livestock grazing. All 75 years from the three simulations (dry, moderate, wet regimes) are included.**

| | Dry Years (< 31.3 inches) | | | Moderate (31.3-42.5 inches) | | | Wet Years (> 42.5 inches) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Rainfall | Annual ET | ET/ Rainfall | Annual Rainfall | Annual ET | ET/ Rainfall | Annual Rainfall | Annual ET | ET/ Rainfall |
| | 14.32 | 1,847,152 | 2.72 | 32.24 | 2,446,095 | 1.60 | 42.67 | 2,580,989 | 1.28 |
| | 16.16 | 2,142,382 | 2.80 | 32.49 | 2,013,577 | 1.31 | 43.04 | 2,469,514 | 1.21 |
| | 18.65 | 2,067,511 | 2.34 | 32.52 | 2,270,540 | 1.47 | 43.08 | 3,099,259 | 1.52 |
| | 19.89 | 2,091,059 | 2.22 | 33.30 | 2,597,213 | 1.65 | 43.16 | 2,835,799 | 1.39 |
| | 20.57 | 2,072,389 | 2.13 | 33.88 | 2,376,399 | 1.48 | 43.25 | 2,672,702 | 1.30 |
| | 22.05 | 2,038,961 | 1.95 | 33.92 | 2,392,197 | 1.49 | 43.32 | 2,662,161 | 1.30 |
| | 22.49 | 2,093,254 | 1.96 | 33.92 | 2,286,998 | 1.42 | 43.46 | 2,764,294 | 1.34 |
| | 23.73 | 2,176,833 | 1.94 | 34.45 | 2,543,510 | 1.56 | 44.61 | 2,739,696 | 1.30 |
| | 25.51 | 2,263,287 | 1.87 | 34.93 | 2,580,913 | 1.56 | 45.07 | 2,616,374 | 1.22 |
| | 25.89 | 2,126,723 | 1.73 | 35.12 | 2,543,834 | 1.47 | 45.62 | 2,778,014 | 1.28 |
| | 26.25 | 2,272,817 | 1.83 | 35.16 | 2,531,592 | 1.52 | 46.67 | 3,219,475 | 1.46 |
| | 27.04 | 2,517,523 | 1.96 | 35.44 | 2,813,786 | 1.68 | 49.28 | 2,797,002 | 1.20 |
| | 27.70 | 2,418,209 | 1.84 | 35.65 | 2,256,511 | 1.34 | 49.29 | 2,942,275 | 1.26 |
| | 29.30 | 2,460,697 | 1.77 | 36.04 | 2,424,864 | 1.42 | 51.00 | 3,197,174 | 1.32 |
| | 30.32 | 2,350,329 | 1.64 | 36.65 | 2,403,841 | 1.38 | 54.82 | 3,044,333 | 1.17 |
| | 30.33 | 2,460,601 | 1.71 | 36.78 | 2,459,037 | 1.41 | 58.40 | 2,986,248 | 1.08 |
| | 30.36 | 2,489,784 | 1.73 | 36.95 | 2,510,102 | 1.43 | 60.07 | 2,985,886 | 1.05 |
| | 30.85 | 2,546,493 | 1.74 | 37.15 | 2,350,676 | 1.34 | 64.99 | 3,055,080 | 0.99 |
| | | | | 37.28 | 3,078,404 | 1.74 | 71.73 | 3,205,797 | 0.94 |
| | | | | 37.44 | 2,387,799 | 1.35 | 73.51 | 3,067,397 | 0.88 |
| | | | | 37.54 | 2,501,361 | 1.41 | | | |
| | | | | 37.57 | 2,568,636 | 1.44 | | | |
| | | | | 37.67 | 2,686,586 | 1.50 | | | |
| | | | | 38.32 | 2,739,972 | 1.51 | | | |
| | | | | 38.54 | 2,449,664 | 1.34 | | | |
| | | | | 39.17 | 2,976,856 | 1.60 | | | |
| | | | | 39.17 | 2,444,676 | 1.32 | | | |
| | | | | 39.19 | 2,517,199 | 1.36 | | | |
| | | | | 39.41 | 2,540,285 | 1.36 | | | |
| | | | | 39.76 | 2,774,495 | 1.47 | | | |
| | | | | 39.96 | 2,766,947 | 1.46 | | | |
| | | | | 39.96 | 2,434,926 | 1.29 | | | |
| | | | | 41.10 | 2,475,176 | 1.27 | | | |
| | | | | 41.98 | 2,448,548 | 1.23 | | | |
| | | | | 42.14 | 2,721,146 | 1.36 | | | |
| | | | | 42.38 | 2,747,028 | 1.37 | | | |
| | | | | 42.38 | 2,550,937 | 1.27 | | | |
| Mean | 24.52 | 2,246,445 | 1.99 | 37.23 | 2,530,063 | 1.44 | 50.85 | 2,885,973 | 1.22 |

Dry year = < 85% of annual mean, moderate year = 85-115% of annual mean, wet year = > 115% of annual mean.
Mean annual rainfall 1898-2015 = 36.91 inches.
Four duplicate years are included, but under different scenarios (moderate or wet).

Conversely, when groundwater is within reach of the vegetation root systems ET generally exceeds annual precipitation. The amount that it exceeds annual precipitation is dependent on depth to groundwater and the maximum productivity (and therefore maximum water requirement) of the vegetation. Mesquite woodland in southeastern Arizona had 33.4 inches of annual ET when depth to groundwater (DTW) was 6.5 feet, compared to 25.1 inches when DTW was at 32.6 feet (Scott et al. 2000, 2006). At DTW = 6.5 feet, the mesquite woodland ET was 33% greater than when DTW was 32.6 feet, and most of this additional water came from groundwater.

In the baseline simulation for Victoria County, annual ET equaled 142% of annual rainfall (Table 9.16) and most of the water for this 42% higher ET came from groundwater. The ratio of annual ET to annual rainfall is one estimate of the amount of groundwater used by vegetation. The highest ratios in the simulations (2.1-2.8) occurred in years with the least rainfall (Table 9.19). In those years (< 21 inches of rainfall), annual ET averaged 2,044,099 acre-feet per year, or about 81% of annual ET during the 37 moderate-rainfall years. This indicates that although the vegetation had access to groundwater during these driest years, the vegetation could not translocate enough groundwater to maintain its average productivity.

As rainfall increased, ET also increased (Table 9.19) but the ratio of ET:rainfall decreased (Fig. 9.3), indicating that the vegetation was becoming less dependent on groundwater. However, it was only in years when rainfall exceeded 64 inches that the vegetation ceased to use groundwater. This value, 64 inches, is one estimate of how much rainfall would be required for the current vegetation in Victoria County to be maintained entirely by rainfall.

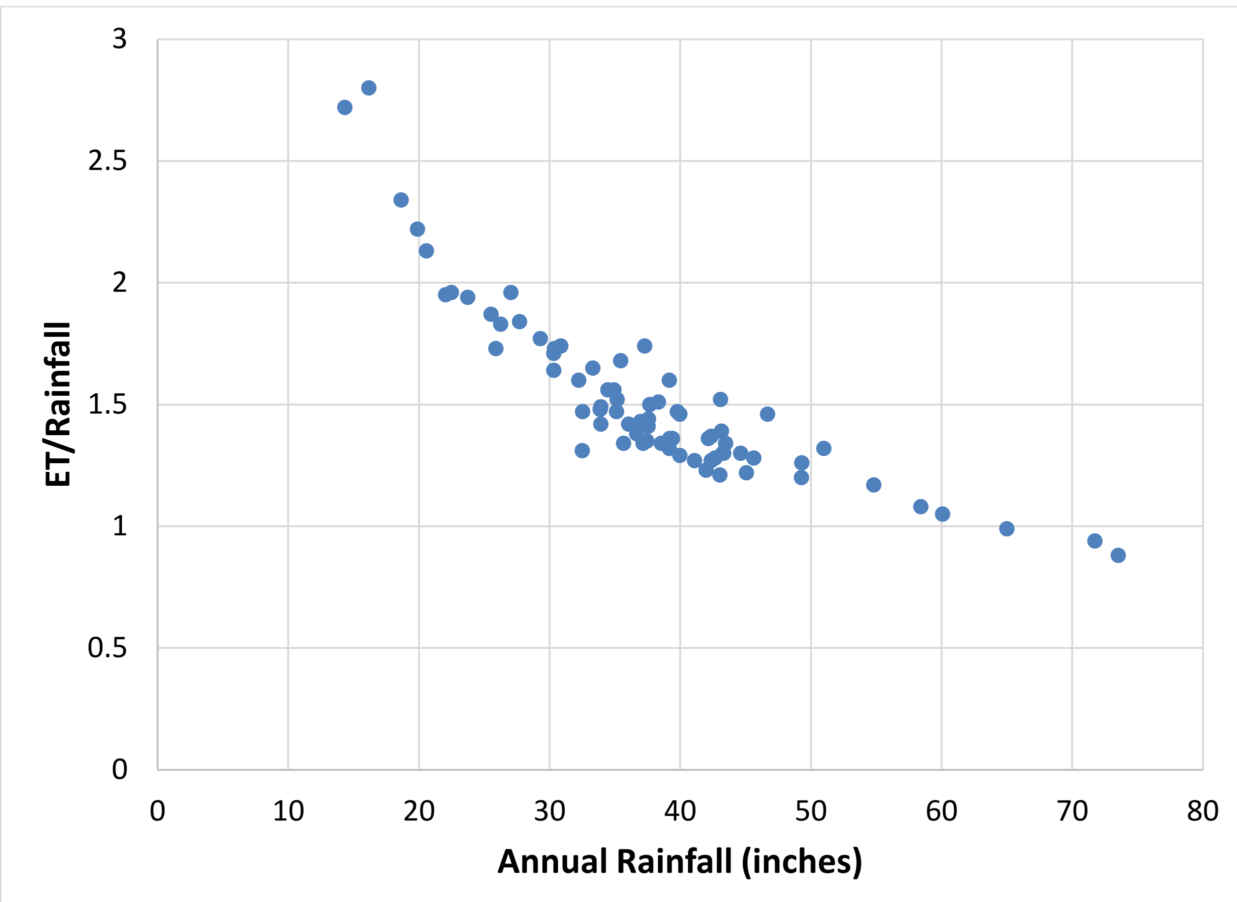


**Figure 9.3 Relationship between the ratio of annual evapotranspiration to annual rainfall (y-axis) and annual rainfall (x-axis) in Victoria County, based on combined results of the dry-, moderate-, and wet-rainfall 25-year EDYS scenarios (data from Table 9.19).**

Cattle grazing reduced ET overall, by 6.0% at moderate stocking rates and by 4.5% at heavy stocking rates, and under the moderate rainfall regime when averaged over 15 years and by 6.3% and 4.9%, respectively, when averaged over 25 years (Table 9.20). This was an equivalent of a reduction of an average of 154,331 acre-feet per year under moderate stocking and 112,671 acre-feet per year under heavy grazing over 15 years and 157,883 acre-feet per year (moderate stocking) and 123,187 acre-feet per year (heavy stocking) when averaged over 25 years. These reductions in ET were the result of less woody biomass and more grass biomass overall with grazing (Table 9.10).

**Table 9.20 Effect of cattle grazing and brush control on annual evapotranspiration (ET) by vegetation averaged over 15-year and 25-year simulations of the Victoria County EDYS model.**

| Scenario | 15-Year Average | | | 25-Year Average | | |
|---|---|---|---|---|---|---|
| | Annual Rainfall (inches) | Annual ET (ac-ft) | ET/ Rainfall | Annual Rainfall (inches) | Annual ET (ac-ft) | ET/ Rainfall |
| Baseline, Average PPT | 37.49 | 2,581,669 | 1.490 | 38.38 | 2,525,071 | 1.416 |
| Baseline, Dry PPT | 35.58 | 2,595,439 | 1.581 | 32,09 | 2,488,040 | 1.701 |
| Baseline, Wet PPT | 41.63 | 2,724,578 | 1.499 | 42.98 | 2,689,201 | 1.422 |
| Moderate Grazing | 37.49 | 2,427,338 | 1.404 | 38.38 | 2,367,188 | 1.383 |
| Heavy Grazing | 37.49 | 2,468,998 | 1.428 | 38.38 | 2,401,884 | 1.350 |
| Brush Control | | | | | | |
| 90% Huisache; Ave PPT | 37.49 | 2,221,820 | 1.278 | 38.38 | 2,279,439 | 1.274 |
| 90% Macartney rose; Ave PPT | 37.49 | 2,567,155 | 1.481 | 38.38 | 2,615,404 | 1.465 |
| 90% Woody; Ave PPT | 37.49 | 1,806,766 | 1.036 | 38.38 | 1,760,040 | 0.982 |
| 90% Woody; Dry PPT | 35.58 | 1,777,870 | 1.080 | 32.09 | 1,651,021 | 1.130 |
| 90% Woody; Wet PPT | 41.63 | 1,956,659 | 1.066 | 42.98 | 1,961,007 | 1.029 |

Baseline scenarios are without cattle grazing and without brush control.
Both Moderate and Heavy Grazing had the Average PPT regime and no brush control.
All brush control scenarios had moderate cattle grazing. In 90% Huisache and 90% Macartney rose scenarios, only those two species were removed. In the 90% Woody scenarios, 90% of all woody species (except only 50% live oak) were removed.

Brush control had a major impact on county-wide ET when applied to all woody species or to only huisache or only to Macartney rose (Table 9.20). Removal of 90% of huisache resulted in an 8% reduction in ET (205,518 acre-feet per year) when averaged over 15 years and a 4% reduction (87,749 acre-feet per year) when averaged over 25 years, with moderate grazing by cattle and the moderate rainfall regime. The reduction in ET was the result of the decrease in huisache and the differences between the 15- and 25-year averages were the result of additional regrowth of huisache during the last 10 years and further increases in grass biomass. Removal of 90% of Macartney rose resulted in an increase in ET because of the corresponding increase in huisache in this scenario (Table 9.13). Although Macartney rose remained at an average of 15% of its untreated levels after 25 years, huisache increased by 13% more than when Macartney rose was untreated. This increase in huisache, along with some increase in grasses, resulted in a higher average ET than when Macartney rose was left untreated. On average over the 15 years following treatment of Macartney rose, ET increased by an average of 139,817 acre-feet per year

(6%) and the average increase over 25 years was 248,216 acre-feet per year (10%). The greater increase over 25 years was the result of further growth of huisache.

Removal of 90% of all woody species (except only 50% of live oak) under the moderate rainfall regime and with moderate grazing by cattle, reduced ET substantially (Table 9.20). When averaged over 15 years, there was an average of 620,572 acre-feet less ET following brush control, a 26% reduction in ET. When averaged over 25 years, there were 607,148 acre-feet less ET per year, also a 26% reduction. The ET/rainfall ratio averaged of the 15 years following brush control was an average of 1.036 per year, compared to 1.404 without brush control (Table 9.20). This low ratio indicates that the post-brush control vegetation was almost in balance with rainfall, i.e., relatively little groundwater was being utilized. This trend of reduced groundwater use continued over the following 10 years. During the last 10 years of the brush control simulation, the ratio averaged 0.902. Averaged over the entire 25-year simulation, the ratio was 0.982. This value is similar to the ratios reported for non-groundwater dependent grasslands, grass-shrublands, and grass-woodlands in Texas: 0.99 for a mesquite-granjeno community in South Texas (Weltz and Blackburn 1995), 0.95 for an oak-grassland in the Edwards Plateau (Thurow et al. 1988), and 0.97 for a mesquite-grassland in the Rolling Plains (Carlson et al. 1990).

Under the dry precipitation regime (mean annual rainfall = 35.6 inches), ET was an average of 28,896 acre-feet per year (2%) less than under the moderate precipitation regime for the first 15 years of the simulation and 109,019 acre-feet per year (6%) less for the full 25 years of the simulation (Table 9.20). The last ten years of the 25 years included the drought years of the 1950s. Under the wet precipitation regime (mean annual rainfall = 41.6 inches), ET was an average of 149,893 acre-feet per year (8%) more than under the moderate precipitation regime for the first 15 years of the simulation and 200,967 acre-feet per year (11%) more for the full 25 years of the simulation. During the first 15 years, the wet regime received an average of 11% more rainfall than under the moderate regime and 12% more when averaged over the 25 years. The fact that ET in the wet regime increased at a lower percentage than rainfall increased is because the vegetation was able to utilize more rainfall-derived soil moisture and utilized less groundwater.

#### 9.2.2.3 Groundwater Use by Vegetation

The baseline scenario (moderate rainfall regime, no livestock grazing) indicated that the vegetation in Victoria County was utilizing an average of 525,375 acre-feet of groundwater per year, or an equivalent of 11.08 inches per year, during the first 15 years of the simulation and 482,327 acre-feet per year (10.18 inches) when averaged over 25 years (Table 9.21). Average annual rainfall increased in the last 10 years of the simulation and this allowed the woody species, which were the primary users of the groundwater, to be less dependent on groundwater during those years. Groundwater use increased, relative to the average rainfall scenario, in the dry scenario because the vegetation became more dependent on groundwater as rainfall decreased. Groundwater accounted for 22-23% of ET during the dry scenario compared to 19-21% during the moderate rainfall scenario (Table 9.21). The amount of groundwater used by vegetation increased in the wet scenario compared to the moderate rainfall scenario, but the proportion of ET contributed by groundwater decreased (18-20%; Table 9.21). Groundwater use in transpiration is a function of both amount (and type) of vegetation and the amount of rainfall-derived soil moisture available to the vegetation. There was more rainfall-derived soil moisture available under the wet regime but there was also more vegetation. The net result was a small increase, about 5,000 acre-feet per year, in groundwater use under the wet regime.

**Table 9.21 Average annual rainfall (inches), average annual groundwater use by vegetation (acre-feet), and proportion of ET contributed by groundwater (GW/ET) under ten Victoria County EDYS simulations, averaged over 15 and 25 years.**

| Simulated Scenario | 15-Year Average | | | 25-Year Average | | |
|---|---|---|---|---|---|---|
| | Rainfall | Groundwater | GW/ET | Rainfall | Groundwater | GW/ET |
| Baseline, Average PPT | 37.49 | 525,375 | 0.209 | 38.38 | 482,327 | 0.193 |
| Baseline, Dry Regime | 35.58 | 552,948 | 0.217 | 32.09 | 544,600 | 0.227 |
| Baseline, Wet Regime | 41.63 | 530,195 | 0.198 | 42.98 | 487,590 | 0.184 |
| Moderate Grazing | 37.49 | 478,867 | 0.200 | 38.38 | 428,843 | 0.183 |
| Heavy Grazing | 37.49 | 495,800 | 0.204 | 38.38 | 442,149 | 0.186 |
| Brush Control | | | | | | |
| 90% Huisache; Ave PPT | 37.49 | 356,682 | 0.163 | 38.38 | 373,093 | 0.166 |
| 90% Macartney rose; Ave PPT | 37.49 | 522,487 | 0.207 | 38.38 | 532,557 | 0.206 |
| 90% Woody; Ave PPT | 37.49 | 171,922 | 0.099 | 38.38 | 147,038 | 0.086 |
| 90% Woody; Dry PPT | 35.58 | 171,632 | 0.100 | 32.09 | 159,988 | 0.100 |
| 90% Woody; Wet PPT | 41.63 | 174,227 | 0.073 | 42.98 | 165,260 | 0.088 |

Baseline scenarios are without cattle grazing and without brush control.
Both Moderate and Heavy Grazing had the Average PPT regime and no brush control.
All brush control scenarios had moderate cattle grazing. In 90% Huisache and 90% Macartney rose scenarios, only those two species were removed. In the 90% Woody scenarios, 90% of all woody species (except only 50% live oak) were removed.

Moderate grazing by cattle reduced vegetation groundwater use by 9% over 15 years and 11% over 25 years (46,508 acre-feet per year and 63,484 acre-feet per year, respectively; Table 9.21). Under heavy grazing by cattle, the reductions were 6% (29,575 acre-feet per year) averaged over 15 years and 8% (40,178 acre-feet per year) averaged over 25 years.

Brush control had a major effect on groundwater use by vegetation (Table 9.21). When only huisache was removed (90%), groundwater use decreased by an average of 122,185 acre-feet per year averaged over 15 years and 55,750 acre-feet per year when averaged over 25 years. These reductions were equal to 26% and 13% of the respective values without brush control (moderate rainfall regime, moderate cattle stocking rates). Huisache comprised over half of the woody species biomass on many vegetation types under baseline conditions and other woody species did not increase sufficiently to offset its removal (Table 9.12). The reverse situation occurred with removal of only Macartney rose. Groundwater use increased because of an increase in huisache, which rapidly replaced Macartney rose (Table 9.20).

Removal of 90% of all woody species (except only 50% of live oak) reduced groundwater use by 64% (306,945 acre-feet per year) averaged over 15 years and 66% (281,805 acre-feet per year) averaged over 25 years, under the moderate rainfall regime and with moderate grazing by cattle (Table 9.21). Under these conditions, less than 10% of ET was coming from groundwater as compared to 19-21% without brush control. Under the dry regime, groundwater use increased by about 13,000 acre-feet per year, averaged over 25 years, because of increased dependence of the remaining woody vegetation on groundwater when there was less rainfall. With brush control applied under the wet regime, groundwater use increased compared to the moderate regime because of increased regrowth of the woody species.

#### 9.2.2.4 Change in Water Balance

In the most basic form, a landscape water balance compares water inputs, exports, and storage across the landscape. For the terrestrial component (i.e., excluding river and stream flows) of the Victoria County model, inputs are from rainfall and groundwater use. Exports are ET, surface runoff, and groundwater recharge (if any). Storage refers to moisture stored in the soil profile. The basic water balance equation is therefore given by:

rainfall + groundwater use = ET + runoff + groundwater recharge + soil storage,

where the soil storage factor is a change (+ or –) in annual amount.

All scenarios except the brush control scenarios in which 90% of the woody species were removed resulted in an average net water deficit over 15 years (Table 9.22). The same was true averaged over 25 years except for the 90% woody species removal under the dry scenario, which had a small deficit. Under both time periods, the deficit was greatest (or surplus the least) under the dry regime and least (or greatest surplus) under the wet regime. Brush control of only huisache or only Macartney rose decreased the soil moisture deficit compared to no removal of the two species, but there remained a deficit. Averaged over 25 years, removal of 90% of woody species resulted in recharge into the vadose zone slightly greater than the groundwater useage under the moderate and wet rainfall regimes. Over longer periods (> 25 years) under either rainfall regime and with this level of brush control, the vadose storage capacity would eventually be exceeded. An annual recharge of 149,495 acre-feet (90% removal of woody species, average rainfall regime) would equal an equivalent of 3.2 inches per year averaged over the entire county. At a 15% available water-holding capacity, this would be the equivalent of 21 inches of soil recharge each year, although in actuality the recharge would be throughout the entire vadose zone because extraction by plants would be occurring throughout the vadose zone. At this rate, an average soil depth of 20 feet (Table 8.8) would be recharged in 11-12 years. Once the storage capacity was reached, further recharge would be into groundwater or lateral flow to creeks and rivers each year. However, without extensive reductions in woody species, it is unlikely that any consistent groundwater recharge will occur in Victoria County as a whole.

Negative net soil water storage cannot be maintained indefinitely. In the model scenarios, the initial soil moisture condition throughout the soil profile was set at 50% of field capacity in each layer, approximating the conditions existing on 1 January of the initial simulation year. Once this stored water is depleted by plants, the vegetation will either 1) utilize more groundwater or 2) adjust to the lower amount of available moisture by reducing the amount of vegetation present and its productivity. The model scenarios were for 25-year simulations. The 275,482 acre-feet

**Table 9.22 Effect of moisture regime, cattle grazing, and brush control on average annual water balance components (acre-feet) averaged over 15- and 25-year periods of 25-year simulations using the Victoria County EDYS model.**

| Scenario | Rainfall | Groundwater Use | Runoff | ET | Net Storage |
|---|---|---|---|---|---|
| **15-Year Means** | | | | | |
| Moisture Regime | | | | | |
| Baseline, Ave PPT | 1,777,685 | 525,375 | 48,289 | 2,581,669 | - 337,340 |
| Baseline, Dry PPT | 1,685,156 | 552,948 | 37,985 | 2,595,439 | - 395,320 |
| Baseline, Wet PPT | 1,974,044 | 530,195 | 58,731 | 2,724,578 | - 279,070 |
| Cattle Grazing | | | | | |
| Moderate Stocking | 1,777,685 | 478,867 | 51,320 | 2,427,338 | - 222,106 |
| Heavy Stocking | 1,777,685 | 495,800 | 50,939 | 2,468,998 | - 246,452 |
| Brush Control | | | | | |
| 90% Huisache; Ave PPT | 1,777,685 | 356,682 | 50,616 | 2,221,820 | - 138,069 |
| 90% Macartney rose; Ave PPT | 1,777,685 | 522,487 | 48,929 | 2,567,155 | - 315,912 |
| 90% Woody; Ave PPT | 1,777,685 | 171,922 | 52,015 | 1,806,766 | + 90,826 |
| 90% Woody; Dry PPT | 1,685,156 | 171,632 | 40,227 | 1,777,870 | + 38,691 |
| 90% Woody; Wet PPT | 1,974,044 | 174,227 | 61,352 | 1,956,659 | + 130,260 |
| **25-Year Means** | | | | | |
| Mositure Regime | | | | | |
| Baseline, Ave PPT | 1,819,587 | 482,327 | 52,325 | 2,525,071 | - 275,482 |
| Baseline, Dry PPT | 1,521,360 | 544,600 | 32,191 | 2,488,040 | - 454,271 |
| Baseline, Wet PPT | 2,037,711 | 487,590 | 59,236 | 2,689,201 | - 223,136 |
| Cattle Grazing | | | | | |
| Moderate Stocking | 1,819,587 | 428,843 | 55,073 | 2,367,188 | - 173,831 |
| Heavy Stocking | 1,819,587 | 442,149 | 54,632 | 2,401,884 | - 194,780 |
| Brush Control | | | | | |
| 90% Huisache; Ave PPT | 1,819,587 | 373,093 | 54,803 | 2,279,439 | - 141,562 |
| 90% Macartney rose; Ave PPT | 1,819,587 | 532,557 | 53,075 | 2,615,404 | - 316,335 |
| 90% Woody; Ave PPT | 1,819,587 | 147,038 | 57,090 | 1,760,040 | + 149,495 |
| 90% Woody; Dry PPT | 1,521,360 | 159,988 | 34,124 | 1,651,021 | - 3,797 |
| 90% Woody, Wet PPT | 2,037,711 | 165,260 | 63,105 | 1,961,007 | + 178,859 |

Baseline = no brush control or livestock grazing.
Brush Control: 90% of target woody species (huisache, Macartney rose, or all woody species expect pecan and 50% of live oak) removed and with moderate cattle grazing.
Cattle grazing scenarios are at the moderate (baseline) rainfall regime.

deficit under the baseline, average rainfall scenario (Table 9.22) equals an average annual deficit of about 5.8 inches of water per year, averaged over the entire county. The actual depth of dewatering varies from year to year as more moisture is added from the top during wet periods and greater amounts are transpired from lower levels during dry periods. In addition, dewatering patterns are very different on wooded sites than on adjacent sites supporting mostly grasses.

### 9.2.3 Water Balance by Watershed

The water balance information presented previously in Section 9.2 was averaged over the entire county. However, landscape hydrology varies widely across the county because of differences in topography, soil, vegetation, and depth to groundwater. There are 46 watersheds delineated in Victoria County (Fig. 9.4), some of which have part of their area outside Victoria County. The watersheds vary in size from less than 10 acres to more than 41,000 acres.

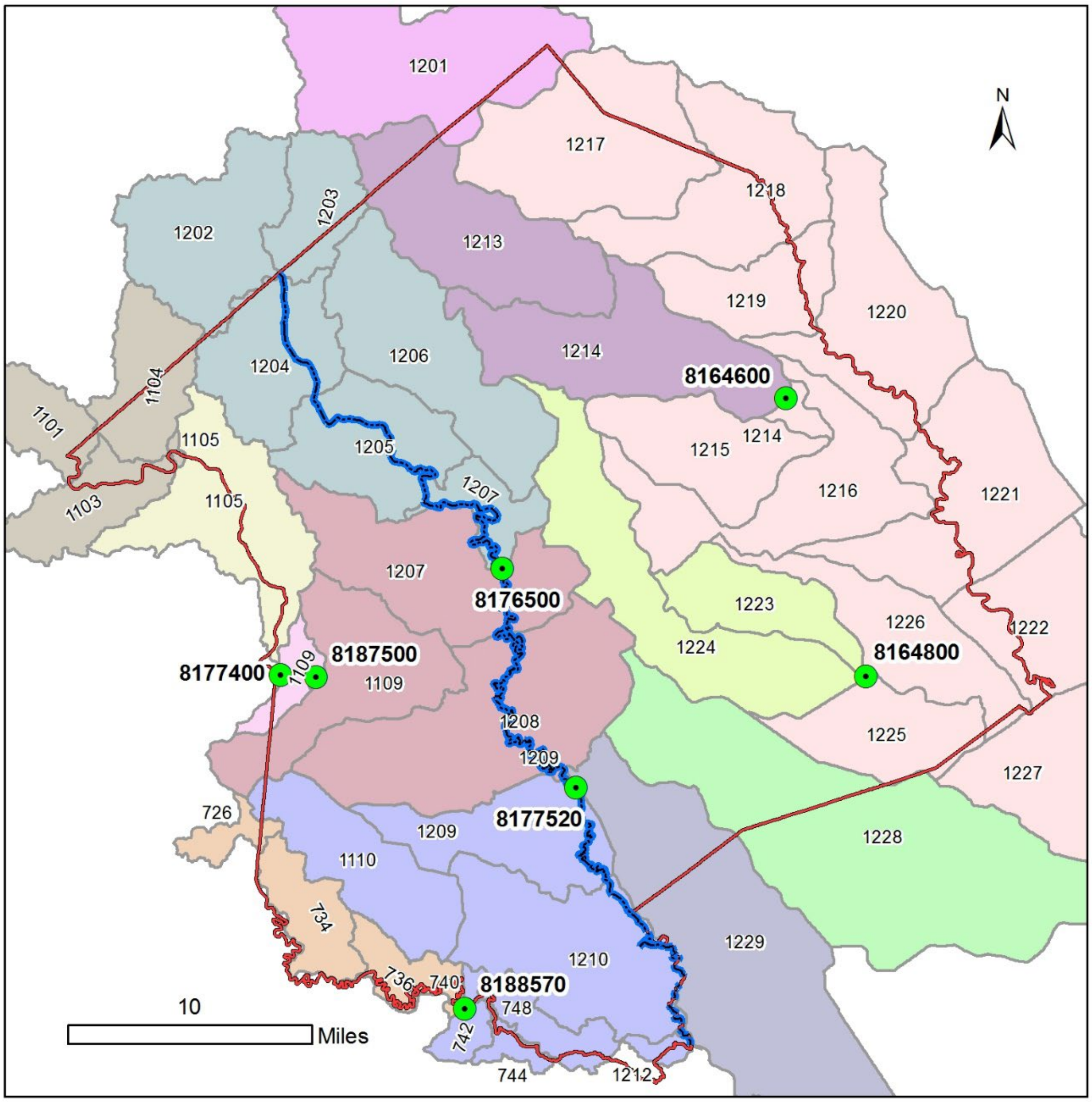


**Figure 9.4 Locations of the 46 watersheds delineated in Victoria County, along with the locations of the associated gauge stations (green circles) for each sector of watersheds.**

In the following sub-sections, data are presented for both 15- and 25-year averages. In both cases, the moderate rainfall regime was used with moderate grazing by cattle. Results are first presented for the 15-year averages without brush control (Scenario 4) and then with brush control, with 90% of woody species removed (Scenario 8). These results are followed by those for the 25-year averages.

#### 9.2.3.1 15-Year Averages Without Brush Control

Per-acre annual ET averaged 51.23 inches county-wide during the first 15 years of the simulation (Table 9.23), but ranged from less than 30 inches in Watershed 1108 between Bloomington and Victoria to more than 100 inches per year in some watersheds in the high water-table areas in the southern part of the county. The very high ET rates occurred in watersheds where groundwater was near, or at, the surface and there was dense vegetation, typically a mosaic of thick stands of trees or shrubs (e.g., Macartney rose) interspersed with dense herbaceous, typically wetland, communities. Although ET rates in excess of 100 inches per year are not typical, they are reasonable for communities similar to those in southern Victoria County, i.e., dense stands of woody vegetation and groundwater near the surface. Dawson (1996) measured daily transpiration rates for sugar maple trees of various sizes at a location where average depth to water was 10 feet (3 m). He found daily transpiration rates for mature trees to average as much as 7 mm per day in some months, with a daily average of 5.4 mm over a five-month growing season. Adjusting for a 12-month growing season in Victoria County, which would probably have higher daily transpiration rates than the maple trees in New York, results in an annual transpiration rate of 78 inches for single trees. These rates were for transpiration alone and did not include evaporation, which may exceed 40% of transpiration (Evans et al. 2013; Mata-Gonzalez et al. 2014). In a study in a tropical woodland, transpiration from trees comprised 49% of ET on an annual basis (Cook et al. 1998).

The sugar maple transpiration rates (Dawson 1996) were for single trees in contact with groundwater. In plant communities with multi-layered canopies, such as those in Victoria County, there would be additional transpiration from smaller trees, shrubs, and herbaceous species located under the tree canopy. The total ET for the vegetation would then be the sum of ET from each of these components. Shrub communities located on sites with shallow groundwater can have ET rates in excess of 50 inches (Devitt et al. 2010), grass communities on shallow groundwater sites may have ET rates of 16-20 inches (Duell 1990; Scott et al. 2000, 2006), and South Texas shrublands have annual ET rates of 34 inches in wet years (Weltz and Blackburn). Dense wetland herbaceous vegetation can have ET rates in excess of 60 inches. Even moderate-density grasslands in Texas have ET rates in excess of 30 inches in wet years (Carlson et al. 1990; Weltz and Blackburn 1995).

Surface runoff averaged 1.09 inches county-wide, for an average annual total of 51,146 acre-feet (Table 9.23). In general, runoff was least (< 1 inch per year) in the northern half of the county and highest (> 2 inches per year) in the extreme southern part of the county (McFaddin Gauge watersheds). Twelve watersheds had annual average runoff of less than 0.9 inch and four watersheds had averages greater than 3 inches per year.

**Table 9.23 Annual water balance components by watershed averaged over the first 15 years of the 25-year simulation with average rainfall regime, moderate grazing by cattle, and no brush control, expressed as watershed totals and per-acre averages, Victoria County EDYS model.**

| Watershed | Area | Rainfall | Watershed Totals (acre-feet) | | | Per-Acre (inches) | | |
|---|---|---|---|---|---|---|---|---|
| | (acres) | (acre-feet) | GW-Use | ET | Runoff | GW-Use | ET | Runoff |
| **Garcitas Gauge (8164600)** | | | | | | | | |
| 1213 | 24,436 | 76,374 | 9,669 | 86,746 | 1,949 | 4.75 | 42.60 | 0.96 |
| 1214 | 31,002 | 96,897 | 15,377 | 115,558 | 2,361 | 5.95 | 44.73 | 0.91 |
| SUM | 55,438 | 173,271 | 25,046 | 202,304 | 4,310 | 5.42 | 43.79 | 0.93 |
| **Matagorda Bay Gauge (5)** | | | | | | | | |
| 1215 | 18,165 | 56,775 | 4,465 | 57,147 | 1,286 | 2.95 | 37.75 | 0.85 |
| 1216 | 26,901 | 84,079 | 13,170 | 94,085 | 2,247 | 5.88 | 41.97 | 1.00 |
| 1217 | 24,714 | 77,244 | 6,007 | 79,760 | 1,423 | 2.92 | 38.73 | 0.69 |
| 1218 | 13,525 | 42,273 | 2,134 | 40,504 | 1,062 | 1.89 | 35.94 | 0.94 |
| 1219 | 11,079 | 34,629 | 4,166 | 37,908 | 771 | 4.51 | 41.06 | 0.84 |
| 1220 | 5,601 | 17,505 | 3,710 | 22,524 | 340 | 7.95 | 48.27 | 0.73 |
| 1221 | 11,232 | 35,106 | 11,658 | 50,376 | 963 | 11.56 | 53.82 | 1.03 |
| 1222 | 4,431 | 13,848 | 11,836 | 33,768 | 774 | 32.05 | 91.45 | 2.10 |
| 1225 | 14,763 | 46,142 | 16,316 | 65,161 | 1,693 | 13.26 | 52.97 | 1.38 |
| 1226 | 18,009 | 56,287 | 37,892 | 121,128 | 1,621 | 25.25 | 80.71 | 1.08 |
| 1227 | 8 | 25 | 4 | 21 | 0 | 6.00 | 31.50 | 0.54 |
| SUM | 148,428 | 463,913 | 111,358 | 602,382 | 12,180 | 9.00 | 48.70 | 0.98 |
| **Victoria Gauge (8176500)** | | | | | | | | |
| 1202 | 232 | 724 | 112 | 884 | 10 | 10.10 | 45.72 | 0.50 |
| 1203 | 2,250 | 7,031 | 1,887 | 10,139 | 81 | 10.24 | 54.07 | 0.43 |
| 1204 | 18,127 | 56,657 | 11,398 | 71,974 | 1,557 | 7.55 | 47.65 | 1.03 |
| 1205 | 19,110 | 59,727 | 17,338 | 85,671 | 1,678 | 10.89 | 53.80 | 1.05 |
| 1206 | 28,469 | 88,978 | 11,278 | 100,461 | 1,757 | 4.75 | 42.35 | 0.74 |
| SUM | 68,188 | 213,117 | 42,013 | 269,129 | 5,083 | 7.39 | 47.36 | 0.89 |
| **Placedo Gauge (8164800)** | | | | | | | | |
| 1223 | 13,135 | 41,054 | 4,851 | 38,075 | 1,205 | 4.43 | 34.78 | 1.10 |
| 1224 | 31,936 | 99,814 | 12,498 | 101,386 | 5,404 | 4.70 | 38.10 | 2.03 |
| SUM | 45,071 | 140,868 | 17,349 | 139,461 | 6,609 | 4.62 | 37.13 | 1.76 |
| **Coleto Gauge (8176900)** | | | | | | | | |
| 1101 | 584 | 1,825 | 458 | 2,540 | 52 | 9.41 | 52.19 | 1.07 |
| 1103 | 2,255 | 7,047 | 1,571 | 9,349 | 170 | 8.36 | 49.75 | 0.90 |
| 1104 | 5,927 | 18,523 | 4,993 | 26,771 | 247 | 10.11 | 54.20 | 0.50 |
| SUM | 8,766 | 27,395 | 7,022 | 38,660 | 469 | 9.61 | 52.96 | 0.64 |
| **McFaddin Gauge (8188570)** | | | | | | | | |
| 722 | 3 | 9 | 24 | 56 | 0 | 96.00 | 224.00 | 1.14 |
| 726 | 465 | 1,452 | 288 | 1,853 | 34 | 7.43 | 47.82 | 0.87 |
| 728 | 320 | 1,001 | 2,140 | 5,071 | 85 | 80.25 | 190.16 | 3.18 |
| 732 | 497 | 1,553 | 2,893 | 7,000 | 169 | 69.85 | 169.01 | 4.08 |
| 734 | 8,869 | 27,718 | 18,975 | 61,059 | 852 | 25.67 | 82.61 | 1.15 |
| 736 | 4,700 | 14,690 | 7,854 | 27,979 | 910 | 20.05 | 71.43 | 2.32 |
| 740 | 39 | 121 | 198 | 493 | 10 | 60.92 | 151.69 | 2.97 |
| SUM | 14,893 | 46,544 | 32,372 | 103,511 | 2,060 | 26.08 | 83.40 | 2.22 |

**Table 9.23 (Cont.)**

| Watershed | Area (acres) | Rainfall (acre-feet) | Watershed Totals (acre-feet) GW-Use | ET | Runoff | Per-Acre (inches) GW-Use | ET | Runoff |
|---|---|---|---|---|---|---|---|---|
| **Bloomington Gauge (8187520)** | | | | | | | | |
| 1105 | 13,293 | 41,547 | 7,005 | 50,825 | 1,218 | 6.32 | 45.88 | 1.10 |
| 1108 | 306 | 955 | 36 | 763 | 128 | 1.41 | 29.92 | 5.04 |
| 1109 | 23,209 | 72,538 | 18,604 | 100,702 | 1,551 | 9.62 | 52.07 | 0.80 |
| 1207 | 35,444 | 110,781 | 24,556 | 142,986 | 3,184 | 8.31 | 48.41 | 1.08 |
| 1208 | 41,476 | 129,633 | 60,629 | 227,382 | 4,376 | 17.54 | 65.79 | 1.27 |
| SUM | 113,728 | 355,454 | 110,830 | 522,658 | 10,457 | 11.69 | 55.15 | 1.10 |
| **Tivoli Gauge (8188800)** | | | | | | | | |
| 742 | 765 | 2,392 | 1,749 | 5,424 | 99 | 27.44 | 85.08 | 1.55 |
| 744 | 399 | 1,247 | 2,229 | 5,460 | 151 | 67.04 | 164.21 | 4.55 |
| 746 | 5 | 16 | 30 | 73 | 1 | 72.00 | 175.20 | 1.76 |
| 748 | 5,125 | 16,019 | 15,816 | 44,255 | 555 | 37.03 | 103.62 | 1.30 |
| 750 | 934 | 2,918 | 1,600 | 5,157 | 90 | 20.58 | 66.33 | 1.16 |
| 1110 | 18,137 | 56,688 | 7,641 | 63,391 | 1,278 | 5.06 | 41.94 | 0.85 |
| 1209 | 18,438 | 57,627 | 32,753 | 111,262 | 2,254 | 21.32 | 72.41 | 1.47 |
| 1210 | 28,273 | 88,368 | 42,208 | 158,908 | 2,167 | 17.91 | 67.44 | 0.92 |
| 1212 | 956 | 2,988 | 2,282 | 6,617 | 133 | 28.64 | 83.06 | 1.67 |
| SUM | 73,032 | 228,261 | 106,309 | 400,547 | 6,728 | 17.19 | 65.81 | 1.11 |
| **San Antonio River South of Bloomington (34)** | | | | | | | | |
| 1228 | 23,016 | 71,936 | 6,599 | 63,043 | 2,026 | 3.43 | 32.87 | 1.06 |
| 1229 | 13,807 | 43,155 | 17,005 | 67,765 | 1,224 | 14.78 | 58.89 | 1.06 |
| SUM | 36,823 | 115,091 | 23,604 | 130,808 | 3,250 | 7.69 | 42.63 | 1.06 |
| **County Totals** | | | | | | | | |
| | 564,367 | 1,763,914 | 475,903 | 2,409,460 | 51,146 | 10.12 | 51.23 | 1.09 |

Total area of Victoria County in Table 9.23 is 564,367 acres instead of the 568,787 acres reported in Section 2.0. The difference is the result of cumulative edge effects in spatial representations of the watersheds.

The simulations indicated that groundwater was utilized by vegetation in all watersheds in the county. Overall mean groundwater use was 10.12 inches per year but the amounts varied substantially among the watersheds (Table 9.23). Most watersheds (34 = 74%) had average annual groundwater use by vegetation of less than 25 inches (Fig. 9.5). Average annual groundwater use was less than 5 inches in 10 watersheds (22%), 5-10 inches per year in 12 (26%), 10-25 inches in 12 (26%), 25-50 inches in six (13%), and more than 50 inches per year in six watersheds (13%). Groundwater use by vegetation was highest in watersheds in the southern part of the county and least in the northeast and central parts of the county.

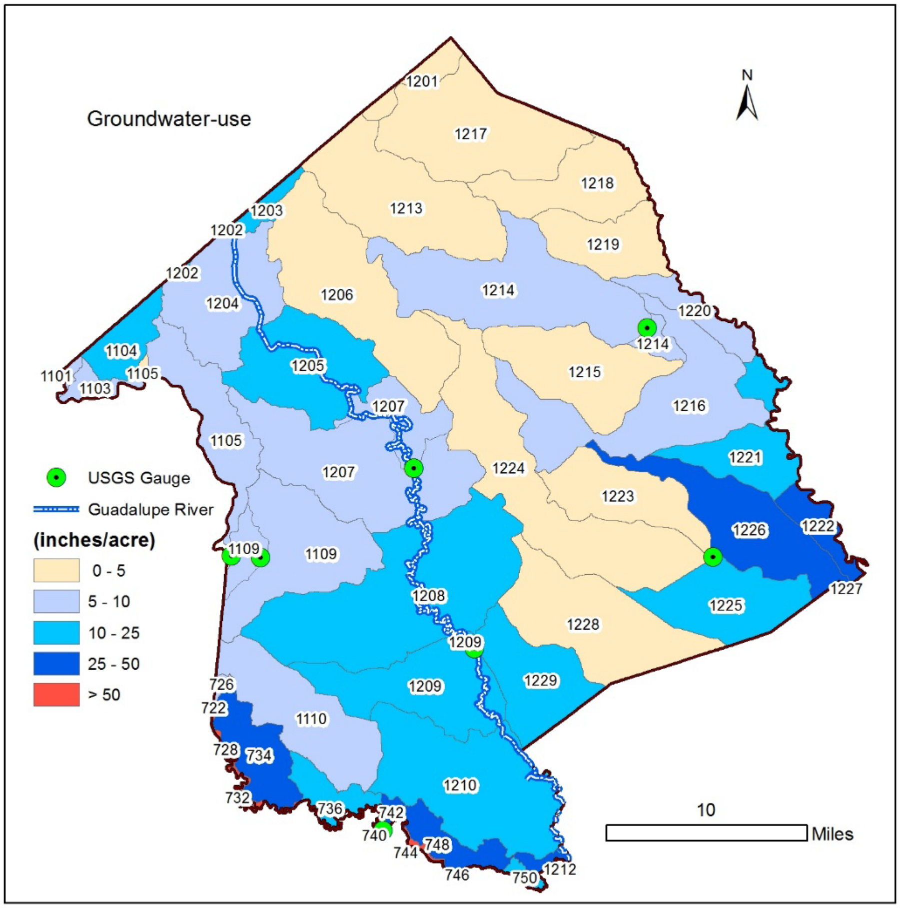


**Figure 9.5 Average annual groundwater-use by vegetation (inches/acre) based on 15-year simulations of the Victoria County EDYS model, with moderate rainfall and cattle grazing but without brush control.**

The ET values (Table 9.23) include groundwater used by vegetation (GW-Use) because the vegetation uses that water as part of plant transpiration. Net water yield from a specific watershed can be estimated by:

$$\text{Net yield} = \text{Rainfall} - \text{ET} + \text{Runoff} + \text{Recharge}.$$

However, the net yield value provided by this equation does not account for change in soil storage. Therefore, only a portion of this estimated net yield would likely leave the watershed in a particular year. Characteristics of the lower soil profile are not well known for most, if not all, the locations. Those edaphic characteristics have a substantial effect on how much water is stored in lower zones and how much is transferred as groundwater recharge or lateral flow into streams and the river, either in the particular watershed or subsurface lateral transfer to adjacent watersheds. Because of this lack of information on deep vadose zone characteristics, net yield cannot be assigned to a specific spatial location. This difficulty is common in ecohydrologic modeling and a better understanding of this linkage between soil moisture storage, groundwater usage, and transpiration by vegetation is a major need in ecohydrologic modeling (Maxwell and Condon 2016).

### 9.2.3.2 Effect of Brush Control on Water Balance, 15-Year Averages

Vegetation is a major factor affecting the water balance and a vegetation component of primary importance influencing this is the amount of woody plants, particularly deep-rooted species. Vegetation dynamics strongly affect both ET and groundwater use. Vegetation dynamics are controlled by both natural and anthropogenic factors. Brush control is one management factor that has substantial impacts on vegetation and therefore on water balance.

The maximum impact of change in woody vegetation, whether from natural (e.g., drought, succession) or anthropogenic causes, on water balance was simulated by applying the brush control option to all non-urban sites throughout the county. In this scenario, 90% of all woody species (except 50% of live oak) were removed in the first year of the simulation and allowed to regrow over the remainder of the simulation. This is not a practical scenario from the standpoint of actual landuse because it is unlikely that all areas would be treated, especially in the same year. However, it is a scenario that estimates the maximum potential effect of brush control on water balance and is useful to determine which areas have the highest potential for increased water yield from brush control. The moderate 25-year rainfall regime (baseline) was used and results would likely be somewhat different under other rainfall regimes.

Maximum potential increased yield was determined by comparing the water balance values from this maximum brush control scenario (Scenario 8) to those from the scenario without brush control (Scenario 4). Three water balance variables (GW-use, ET, and runoff) were compared. Decreases in GW-use and ET were considered to be net increases in water yield although there would likely be a lag-time before decreased ET might result in increases in groundwater or subsurface flows into streams and the river.

Brush control had a major impact on the water balances in the simulations (Table 9.24). There was an overall (county-wide) reduction in ET of 616,708 acre-feet per year, or a reduction of over 25% from the no brush control scenario. Almost half (49%) of this reduction in ET was because of reduced groundwater extraction by the vegetation. The remaining 51% was from reduced transpiration of soil moisture and reduced evaporation from rainfall intercepted by the plant canopy. Under this brush control scenario, average annual total ET (including groundwater use) was simulated to be 1,792,752 acre-feet (Table 9.24), or 101.6% of average annual rainfall (1,763,914 acre-feet; Table 9.23). Averaged over three years, ET/rainfall ratios at a South Texas site were 99% for a mesquite shrubland (Weltz and Blackburn 1995). Similar values have been reported for mesquite-grasslands in the Rolling Plains of Texas (97%; Carlson et al. 1990), oak-grasslands in the Edwards Plateau (95%; Thurow et al. 1988), and bluestem prairie in Kansas (94%; Bremer et al. 2001). The simulated brush control scenario left half of the live oak in place, which continued to utilize groundwater, and the larger grasses on the shallow-groundwater sites also continued to utlize groundwater. Therefore, the 102% ratio from the brush control scenario seems reasonable.

**Table 9.24 Differences in average annual water balance components (acre-feet) between no brush control (Scenario 4) and brush control (Scenario 8, 90% of woody species) simulations averaged over the first 15 years under the moderate rainfall regime and with moderate livestock grazing using the Victoria County EDYS model.**

| Watershed | Area | No Brush Control | | | With Brush Control | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (acres) | GW-Use | ET | Runoff | GW-Use | ET | Runoff | GW-Use | ET | Runoff |
| **Garcitas Gauge (8164600)** | | | | | | | | | | |
| 1213 | 24,436 | 9,669 | 86,746 | 1,949 | 3,831 | 74,442 | 1,915 | 5,838 | 12,304 | 34 |
| 1214 | 31,002 | 15,377 | 115,558 | 2,361 | 7,295 | 98,690 | 2,311 | 8,082 | 16,868 | 50 |
| SUM | 55,438 | 25,046 | 202,304 | 4,310 | 11,126 | 173,132 | 4,226 | 13,920 | 29,172 | 84 |
| **Matagorda Bay Gauge (5)** | | | | | | | | | | |
| 1215 | 18,165 | 4,465 | 57,147 | 1,286 | 617 | 49,330 | 1,249 | 3,848 | 7,817 | 37 |
| 1216 | 26,901 | 13,170 | 94,085 | 2,247 | 3,269 | 74,443 | 2,267 | 9,901 | 19,642 | - 20 |
| 1217 | 24,714 | 6,007 | 79,760 | 1,423 | 2,656 | 72,436 | 1,395 | 3,351 | 7,324 | 28 |
| 1218 | 13,525 | 2,134 | 40,504 | 1,062 | 925 | 37,827 | 1,036 | 1,209 | 2,677 | 26 |
| 1219 | 11,079 | 4,166 | 37,908 | 771 | 2,121 | 34,103 | 721 | 2,045 | 3,805 | 50 |
| 1220 | 5,601 | 3,710 | 22,524 | 340 | 1,099 | 17,232 | 333 | 2,611 | 5,292 | 7 |
| 1221 | 11,232 | 11,658 | 50,376 | 963 | 3,571 | 34,580 | 976 | 8,087 | 15,796 | - 13 |
| 1222 | 4,431 | 11,836 | 33,768 | 774 | 5,997 | 21,904 | 804 | 5,839 | 11,864 | - 30 |
| 1225 | 14,763 | 16,316 | 65,161 | 1,693 | 5,363 | 44,767 | 1,694 | 10,953 | 20,394 | - 1 |
| 1226 | 18,009 | 37,892 | 121,128 | 1,621 | 12,818 | 71,093 | 1,660 | 25,074 | 50,035 | - 39 |
| 1227 | 8 | 4 | 21 | 0 | 3 | 19 | 0 | 1 | 2 | 0 |
| SUM | 148,428 | 111,358 | 602,382 | 12,180 | 38,439 | 457,734 | 12,135 | 72,919 | 144,648 | 45 |
| **Victoria Gauge (8176500)** | | | | | | | | | | |
| 1202 | 232 | 112 | 884 | 10 | 36 | 712 | 10 | 76 | 172 | 0 |
| 1203 | 2,250 | 1,887 | 10,139 | 81 | 802 | 7,912 | 79 | 1,085 | 2,227 | 2 |
| 1204 | 18,127 | 11,398 | 71,974 | 1,557 | 3,616 | 55,942 | 1,568 | 7,782 | 16,032 | - 11 |
| 1205 | 19,110 | 17,338 | 85,671 | 1,678 | 4,451 | 59,191 | 1,735 | 12,887 | 26,480 | - 57 |
| 1206 | 28,469 | 11,278 | 100,461 | 1,757 | 2,740 | 82,053 | 1,772 | 8,538 | 18,408 | - 15 |
| SUM | 68,188 | 42,013 | 269,129 | 5,083 | 11,645 | 205,810 | 5,164 | 30,368 | 63,319 | - 81 |
| **Placedo Gauge (8164800)** | | | | | | | | | | |
| 1223 | 13,135 | 4,851 | 38,075 | 1,205 | 741 | 31,543 | 1,184 | 4,110 | 6,532 | 21 |
| 1224 | 31,936 | 12,498 | 101,386 | 5,404 | 2,470 | 82,813 | 5,393 | 10,028 | 18,573 | 11 |
| SUM | 45,071 | 17,349 | 139,461 | 6,609 | 3,211 | 114,356 | 6,577 | 14,138 | 25,105 | 32 |
| **Coleto Gauge (8176900)** | | | | | | | | | | |
| 1101 | 584 | 458 | 2,540 | 52 | 316 | 2,240 | 52 | 142 | 300 | 0 |
| 1103 | 2,255 | 1,571 | 9,349 | 170 | 1,101 | 8,365 | 171 | 470 | 984 | - 1 |
| 1104 | 5,927 | 4,993 | 26,771 | 247 | 2,370 | 21,156 | 254 | 2,623 | 5,615 | - 7 |
| SUM | 8,766 | 7,022 | 38,660 | 469 | 3,787 | 31,761 | 477 | 3,235 | 6,899 | - 8 |
| **McFaddin Gauge (8188570)** | | | | | | | | | | |
| 722 | 3 | 24 | 56 | 0 | 6 | 17 | 0 | 18 | 39 | 0 |
| 726 | 465 | 288 | 1,853 | 34 | 61 | 1,349 | 37 | 227 | 504 | - 3 |
| 728 | 320 | 2,140 | 5,071 | 85 | 529 | 1,787 | 104 | 1,611 | 3,284 | - 19 |
| 732 | 497 | 2,893 | 7,000 | 169 | 810 | 2,746 | 192 | 2,083 | 4,254 | - 23 |
| 734 | 8,869 | 18,975 | 61,059 | 852 | 5,605 | 33,459 | 917 | 13,370 | 27,600 | - 65 |
| 736 | 4,700 | 7,854 | 27,979 | 910 | 2,396 | 16,680 | 991 | 5,458 | 11,299 | - 81 |
| 740 | 39 | 198 | 493 | 10 | 64 | 222 | 10 | 134 | 271 | 0 |
| SUM | 14,893 | 32,372 | 103,511 | 2,060 | 9,471 | 56,260 | 2,251 | 22,901 | 47,251 | -191 |

**Table 9.24 (Cont.)**

| Watershed | Area | No Brush Control | | | With Brush Control | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (acres) | GW-Use | ET | Runoff | GW-Use | ET | Runoff | GW-Use | ET | Runoff |
| **Bloomington Gauge (8187520)** | | | | | | | | | | |
| 1105 | 13,293 | 7,005 | 50,825 | 1,218 | 3,066 | 42,509 | 1,221 | 3,939 | 8,316 | - 3 |
| 1108 | 306 | 36 | 763 | 128 | 21 | 730 | 128 | 15 | 33 | 0 |
| 1109 | 23,209 | 18,604 | 100,702 | 1,551 | 6,675 | 75,762 | 1,599 | 11,929 | 24,940 | - 48 |
| 1207 | 35,444 | 24,556 | 142,986 | 3,184 | 6,814 | 106,000 | 3,253 | 17,742 | 36,986 | - 69 |
| 1208 | 41,476 | 60,629 | 227,382 | 4,376 | 19,257 | 142,609 | 4,573 | 41,372 | 84,773 | -197 |
| SUM | 113,728 | 110,830 | 522,658 | 10,457 | 35,833 | 367,610 | 10,774 | 74,997 | 155,048 | -317 |
| **Tivoli Gauge (8188800)** | | | | | | | | | | |
| 742 | 765 | 1,749 | 5,424 | 99 | 763 | 3,402 | 106 | 986 | 2,022 | - 7 |
| 744 | 399 | 2,229 | 5,460 | 151 | 681 | 2,314 | 169 | 1,548 | 3,146 | - 18 |
| 746 | 5 | 30 | 73 | 1 | 9 | 30 | 1 | 21 | 43 | 0 |
| 748 | 5,125 | 15,816 | 44,255 | 555 | 8,159 | 28,868 | 578 | 7,657 | 15,387 | - 23 |
| 750 | 934 | 1,600 | 5,157 | 90 | 1,287 | 4,675 | 83 | 313 | 482 | 7 |
| 1110 | 18,137 | 7,641 | 63,391 | 1,278 | 857 | 48,848 | 1,375 | 6,784 | 14,543 | - 97 |
| 1209 | 18,438 | 32,753 | 111,262 | 2,254 | 13,269 | 71,220 | 2,329 | 19,484 | 40,042 | - 75 |
| 1210 | 28,273 | 42,208 | 158,908 | 2,167 | 19,832 | 112,961 | 2,249 | 22,376 | 45,947 | - 82 |
| 1212 | 956 | 2,282 | 6,617 | 133 | 1,407 | 4,985 | 127 | 875 | 1,632 | 6 |
| SUM | 73,032 | 106,308 | 400,547 | 6,728 | 46,264 | 277,303 | 7,017 | 60,044 | 123,244 | -289 |
| **San Antonio River South of Bloomington (34)** | | | | | | | | | | |
| 1228 | 23,016 | 6,599 | 63,043 | 2,026 | 2,600 | 57,973 | 1,989 | 3,999 | 5,070 | 37 |
| 1229 | 13,807 | 17,005 | 67,765 | 1,224 | 8,439 | 50,813 | 1,227 | 8,566 | 16,952 | - 3 |
| SUM | 36,823 | 23,604 | 130,808 | 3,250 | 11,039 | 108,786 | 3,216 | 12,565 | 22,022 | 34 |
| **County Totals** | | | | | | | | | | |
| | 564,367 | 475,902 | 2,409,460 | 51,146 | 170,815 | 1,792,752 | 51,837 | 305,087 | 616,708 | -691 |

Total area of Victoria County in Table 9.24 is 564,367 acres instead of the 568,787 acres reported in Section 2.0. The lower value is the result of cumulative edge effects in spatial representations of the watersheds.
Difference = (No Brush Control Value) – (With Brush Control Value).

Although annual average ET was slightly greater than average annual rainfall when averaged over the entire county, annual ET following brush control was less than annual rainfall in 21 of the 46 watersheds (Table 9.25). These 21 watersheds contained a total of 338,801 acres, or 60% of the area of the county. Prior to brush control, only five of these watersheds, with a total of 49,990 acres, had annual ET less than annual rainfall (Table 9.23). The average ET:rainfall ratio for the 21 watersheds following brush control was 0.89 (total per acre basis).

**Table 9.25 Annual ET/Annual Rainfall ratios for the 46 watersheds in Victoria County following the brush control (Scenario 8) simulation, Victoria County EDYS model.**

| Watersheds With Ratios Less Than 1.00 | | | | | Watersheds with Ratios 1.00 or Higher | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Watershed | Area (acres) | Rainfall (acre-feet) | ET (acre-feet) | Ratio | Watershed | Area (acres) | Rainfall (acre-feet) | ET (acre-feet) | Ratio |
| **Garcitas Gauge (8164600)** | | | | | | | | | |
| 1213 | 24,436 | 76,374 | 74,442 | 0.97 | 1214 | 31,002 | 96,897 | 98,690 | 1.02 |
| **Matagorda Bay Gauge (5)** | | | | | | | | | |
| 1215 | 18,165 | 56,775 | 49,330 | 0.87 | 1222 | 4,431 | 13,848 | 21,904 | 1.58 |
| 1216 | 26,901 | 84,079 | 74,443 | 0.89 | 1226 | 18,009 | 56,287 | 71,093 | 1.26 |
| 1217 | 24,714 | 77,244 | 72,436 | 0.94 | | | | | |
| 1218 | 13,525 | 42,273 | 37,827 | 0.89 | | | | | |
| 1219 | 11,079 | 34,629 | 34,103 | 0.98 | | | | | |
| 1220 | 5,601 | 17,505 | 17,232 | 0.98 | | | | | |
| 1221 | 11,232 | 35,106 | 34,580 | 0.99 | | | | | |
| 1225 | 14,763 | 46,142 | 44,767 | 0.97 | | | | | |
| 1227 | 8 | 25 | 19 | 0.77 | | | | | |
| **Victoria Gauge (8176500)** | | | | | | | | | |
| 1202 | 232 | 724 | 712 | 0.98 | 1203 | 2,250 | 7,031 | 7,912 | 1.13 |
| 1204 | 18,127 | 56,657 | 55,942 | 0.99 | | | | | |
| 1205 | 19,110 | 59,727 | 59,191 | 0.99 | | | | | |
| 1206 | 28,469 | 88,978 | 82,053 | 0.92 | | | | | |
| **Placedo Gauge (8164800)** | | | | | | | | | |
| 1223 | 13,135 | 41,054 | 31,543 | 0.77 | | | | | |
| 1224 | 31,936 | 99,814 | 82,813 | 0.83 | | | | | |
| **Coleto Gauge (8176900)** | | | | | | | | | |
| | | | | | 1101 | 584 | 1,825 | 2,240 | 1.23 |
| | | | | | 1103 | 2,255 | 7,047 | 8,365 | 1.19 |
| | | | | | 1104 | 5,927 | 18,523 | 21,156 | 1.14 |
| **McFaddin Gauge (8188570)** | | | | | | | | | |
| 726 | 465 | 1,452 | 1,349 | 0.93 | 722 | 3 | 9 | 17 | 2.02 |
| | | | | | 728 | 320 | 1,001 | 1,787 | 1.79 |
| | | | | | 732 | 497 | 1,553 | 2,746 | 1.77 |
| | | | | | 734 | 8,869 | 27,718 | 33,459 | 1.21 |
| | | | | | 736 | 4,700 | 14,690 | 16,680 | 1.14 |
| | | | | | 740 | 39 | 121 | 222 | 1.83 |
| **Bloomington Gauge (8187520)** | | | | | | | | | |
| 1108 | 306 | 955 | 730 | 0.76 | 1105 | 13,293 | 41,547 | 42,509 | 1.02 |
| 1207 | 35,444 | 110,781 | 106,000 | 0.96 | 1109 | 23,209 | 72,538 | 75,762 | 1.04 |
| | | | | | 1208 | 41,476 | 129,633 | 142,609 | 1.10 |
| **Tivoli Gauge (8188800)** | | | | | | | | | |
| 1110 | 18,137 | 56,688 | 48,848 | 0.86 | 742 | 765 | 2,392 | 3,402 | 1.42 |
| | | | | | 744 | 399 | 1,247 | 2,314 | 1.86 |
| | | | | | 746 | 5 | 16 | 30 | 1.86 |
| | | | | | 748 | 5,125 | 16,019 | 28,868 | 1.80 |
| | | | | | 750 | 933 | 2,918 | 4,675 | 1.60 |
| | | | | | 1209 | 18,438 | 57,627 | 71,220 | 1.24 |
| | | | | | 1210 | 28,273 | 88,368 | 112,961 | 1.28 |
| | | | | | 1212 | 956 | 2,988 | 4,985 | 1.67 |
| **San Antonio River South of Bloomington (34)** | | | | | | | | | |
| 1228 | 23,016 | 71,936 | 57,973 | 0.81 | 1229 | 13,807 | 43,155 | 50,813 | 1.18 |

### 9.2.3.3 Maximum Potential Water Yield Enhancement, 15-Year Average Basis

Enhancement of water yield from the maximum brush control scenario would not be uniform across the county. It would be higher in areas with heavier stands of woody species and lower in areas with lighter stands. Enhancement also varies in response to difference in soils (e.g., texture and depth) and species of woody species present in the vegetation (e.g., mesquite and live oak are deep-rooted species, whereas hackberry and blackbrush have shallower root systems; Appendix Table D.9).

Simulated maximum potential water yield enhancement was calculated for each watershed (Table 9.26) as the difference in ET between no brush control (Scenario 4) and brush control (Scenario 8) scenarios minus difference in runoff between the two scenarios (Table 9.24), under the average rainfall regime and with moderate livestock grazing. It is unlikely that brush control treatments would, in practice, be applied to an entire watershed. Instead, applications are likely to be applied to only parts of a particular watershed. Although the enhanced water yield that would occur from a brush control operation will vary even within a watershed because of differences in vegetation, soils, and topography within the watershed, expressing potential water yield enhancement on a per acre basis provides a useful metric to compare potential benefits among watersheds.

Maximum potential enhancement of water yield from brush control for the entire county was 671,399 acre-feet per year, averaged over the first 15 years following brush control, or an average of 13.1 inches per acre annually (Table 9.26). This was equal to 25.6% of total ET without brush control. Nine of the 46 watersheds (20%) had potential average increased annual yields of less than 6 inches per acre, 14 (30%) between 6-12 inches, 9 (20%) between 12-24 inches, 6 (13%) between 24-36 inches, and 8 (17%) more than 36 inches per year (Fig. 9.6).

Potential increase in water yield from brush control is the result of two primary factors: 1) decreased ET because of less, and different types of, vegetation and 2) lower groundwater use because of a reduction in amount of deep-rooted woody species. Overall, almost half (305,087 acre-feet per year; 6.5 inches per acre per year) of the potential increase in water yield in the simulations occurred from lower groundwater use (Table 9.26). As with enhanced water yield overall, reduction in groundwater use varied considerably among watersheds (Fig. 9.7).

**Table 9.26 Maximum potential annual (15-year averages) water yield enhancement and decrease in groundwater use by vegetation (GW-Use) resulting from the maximum brush control scenario using the Victoria County EDYS model. ET values are average annual decreases and runoff values are average annual increases (net yield = decreased ET + increased runoff).**

| Watershed | Area | Enhanced Yield (acre-feet) | | | Per Acre Basis | Decrease in GW-Use[1] | |
|---|---|---|---|---|---|---|---|
| | (acres) | ET | Runoff | Net Yield | (inches/acre) | (acre-feet) | (inches/acre) |
| **Garcitas Gauge (8164600)** | | | | | | | |
| 1213 | 24,436 | 12,304 | - 34 | 12,270 | 6.03 | 5,838 | 2.87 |
| 1214 | 31,002 | 16,868 | - 50 | 16,818 | 6.51 | 8,082 | 3.13 |
| SUM | 55,438 | 29,172 | - 84 | 29,088 | 6.30 | 13,920 | 3.01 |
| **Matagorda Bay Gauge (5)** | | | | | | | |
| 1215 | 18,165 | 7,817 | - 37 | 7,780 | 5.14 | 3,848 | 2.54 |
| 1216 | 26,901 | 19,642 | 20 | 19,662 | 8.77 | 9,901 | 4.42 |
| 1217 | 24,714 | 7,324 | - 28 | 7,296 | 3.54 | 3,351 | 1.63 |
| 1218 | 13,525 | 2,677 | - 26 | 2,651 | 2.35 | 1,209 | 1.07 |
| 1219 | 11,079 | 3,805 | - 50 | 3,755 | 4.07 | 2,045 | 2.21 |
| 1220 | 5,601 | 5,292 | - 7 | 5,285 | 11.32 | 2,611 | 5.59 |
| 1221 | 11,232 | 15,796 | 13 | 15,809 | 16.89 | 8,087 | 8.64 |
| 1222 | 4,431 | 11,864 | 30 | 11,894 | 32.21 | 5,839 | 15.81 |
| 1225 | 14,763 | 20,394 | 1 | 20,395 | 16.58 | 10,953 | 8.23 |
| 1226 | 18,009 | 50,035 | 39 | 50,074 | 33.37 | 25,074 | 16.71 |
| 1227 | 8 | 2 | 0 | 2 | 3.00 | 1 | 1.50 |
| SUM | 148,428 | 144,648 | - 45 | 144,603 | 11.69 | 72,919 | 5.90 |
| **Victoria Gauge (8176500)** | | | | | | | |
| 1202 | 232 | 172 | 0 | 172 | 8.90 | 76 | 3.93 |
| 1203 | 2,250 | 2,227 | - 2 | 2,225 | 11.87 | 1,085 | 5.79 |
| 1204 | 18,127 | 16,032 | 11 | 16,043 | 10.62 | 7,782 | 5.15 |
| 1205 | 19,110 | 26,480 | 57 | 26,537 | 16.66 | 12,887 | 8.09 |
| 1206 | 28,469 | 18,408 | 15 | 18,423 | 7.77 | 8,538 | 3.60 |
| SUM | 68,188 | 63,319 | 81 | 63,400 | 11.16 | 30,368 | 5.34 |
| **Placedo Gauge (8164800)** | | | | | | | |
| 1223 | 13,135 | 6,532 | - 21 | 6,511 | 5.95 | 4,110 | 3.75 |
| 1224 | 31,936 | 18,573 | - 11 | 18,562 | 6.98 | 10,028 | 3.77 |
| SUM | 45,071 | 25,105 | - 32 | 25,073 | 6.68 | 14,138 | 3.76 |
| **Coleto Gauge (8176900)** | | | | | | | |
| 1101 | 584 | 300 | 0 | 300 | 6.16 | 142 | 2.92 |
| 1103 | 2,255 | 984 | 1 | 985 | 5.24 | 470 | 2.50 |
| 1104 | 5,927 | 5,615 | 7 | 5,622 | 11.38 | 2,623 | 5.31 |
| SUM | 8,766 | 6,899 | 8 | 6,907 | 9.46 | 3,235 | 4.43 |
| **McFaddin Gauge (8188570)** | | | | | | | |
| 722 | 3 | 39 | 0 | 39 | 156.00 | 18 | 72.00 |
| 726 | 465 | 504 | 3 | 507 | 13.08 | 227 | 5.88 |
| 728 | 320 | 3,284 | 19 | 3,303 | 123.86 | 1,611 | 60.41 |
| 732 | 497 | 4,254 | 23 | 4,277 | 103.27 | 2,083 | 50.29 |
| 734 | 8,869 | 27,600 | 65 | 27,665 | 37.42 | 13,370 | 18.09 |
| 736 | 4,700 | 11,299 | 81 | 11,380 | 29.06 | 5,458 | 13.93 |
| 740 | 39 | 271 | 0 | 271 | 83.38 | 134 | 41.23 |
| SUM | 14,893 | 47,251 | 191 | 47,442 | 38.23 | 22,901 | 18.45 |

**Table 9.26 (Cont.)**

| Watershed | Area (acres) | Enhanced Yield (acre-feet) ET | Runoff | Net Yield | Per Acre Basis (inches/acre) | Decrease in GW-Use[1] (acre-feet) | (inches/acre) |
|---|---|---|---|---|---|---|---|
| **Bloomington Gauge (8187520)** | | | | | | | |
| 1105 | 13,293 | 8,316 | 3 | 8,319 | 7.51 | 3,939 | 3.56 |
| 1108 | 306 | 33 | 0 | 33 | 1.29 | 15 | 0.59 |
| 1109 | 23,209 | 24,940 | 48 | 24,988 | 12.92 | 11,929 | 6.17 |
| 1207 | 35,444 | 36,986 | 69 | 37,055 | 12.55 | 17,742 | 6.01 |
| 1208 | 41,476 | 84,773 | 197 | 84,970 | 24.58 | 41,372 | 11.97 |
| SUM | 113,728 | 155,048 | 317 | 155,365 | 16.39 | 74,997 | 7.91 |
| **Tivoli Gauge (8188800)** | | | | | | | |
| 742 | 765 | 2,022 | 7 | 2,029 | 31.83 | 986 | 15.44 |
| 744 | 399 | 3,146 | 18 | 3,164 | 95.66 | 1,548 | 46.56 |
| 746 | 5 | 43 | 0 | 43 | 103.20 | 21 | 50.40 |
| 748 | 5,125 | 15,387 | 23 | 15,410 | 36.08 | 7,657 | 18.07 |
| 750 | 934 | 482 | - 7 | 475 | 6.10 | 313 | 4.02 |
| 1110 | 18,137 | 14,543 | 97 | 14,640 | 9.68 | 6,784 | 4.49 |
| 1209 | 18,438 | 40,042 | 75 | 40,117 | 26.11 | 19,484 | 12.68 |
| 1210 | 28,273 | 45,947 | 82 | 46,029 | 19.54 | 22,376 | 9.50 |
| 1212 | 956 | 1,632 | - 6 | 1,626 | 20.41 | 875 | 10.98 |
| SUM | 73,032 | 123,244 | 289 | 123,533 | 20.30 | 60,044 | 9.87 |
| **San Antonio River South of Bloomington (34)** | | | | | | | |
| 1228 | 23,016 | 5,070 | - 37 | 5,033 | 2.62 | 3,999 | 2.08 |
| 1229 | 13,807 | 16,952 | 3 | 16,955 | 14.74 | 8,566 | 7.45 |
| SUM | 36,823 | 22,022 | - 34 | 21,988 | 7.17 | 12,565 | 4.10 |
| **County Totals** | | | | | | | |
| | 564,367 | 616,708 | 691 | 617,399 | 13.13 | 305,087 | 6.49 |

[1] Groundwater use amounts are included in the ET amounts (i.e., groundwater-use is part of the plant transpiration).

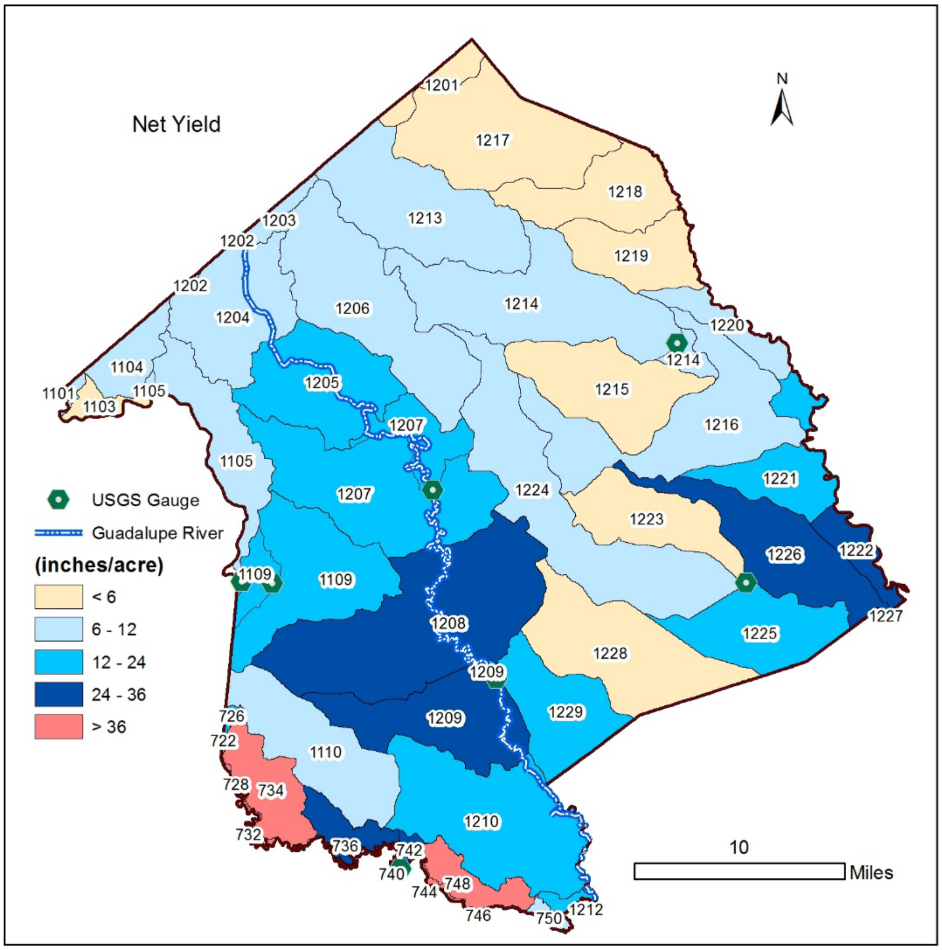


**Figure 9.6 Maximum potential increased annual water yield (inches/acre) from brush control based on 15-year simulations of the Victoria EDYS model using the moderate rainfall regime.**

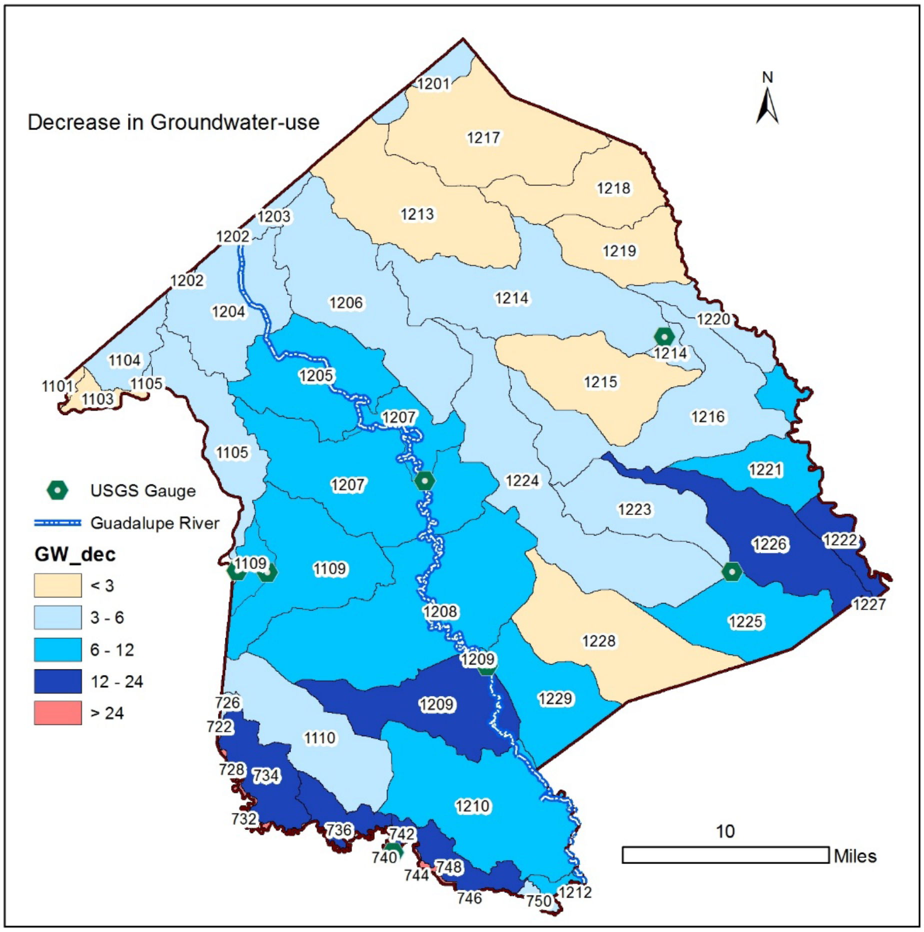


**Figure 9.7 Decrease in annual groundwater use by vegetation (inches/acre) from maximum brush control based on 15-year simulations of the Victoria EDYS model using the moderate rainfall regime.**

### 9.2.3.4 25-Year Averages Without Brush Control

Per-acre annual ET averaged 49.95 inches county-wide over the 25 years of the simulation (Table 9.27), compared to an average of 51.23 inches during the first 15 years. Surface runoff averaged 1.17 inches per year over the 25 years, for an average annual total of 54,884 acre-feet. Average annual rainfall was 38.38 inches over the 25 years, compared to 37.49 inches over the first 15 years. The higher 25-year average rainfall was the primary factor for the higher 25-year annual runoff (1.17 inches) than the 15-year average of 1.09 inches. The lower ET when averaged over 25 years was the result of vegetation changes during the last 10 years of the simulation (Tables 9.1, 9.4, and 9.5).

**Table 9.27 Annual water balance components by watershed averaged over the 25-year simulation with average rainfall regime, moderate grazing by cattle, and no brush control, expressed as watershed totals and per-acre averages, Victoria County EDYS model.**

| Watershed | Area (acres) | Rainfall (acre-feet) | Watershed Totals (acre-feet) GW-Use | ET | Runoff | Per Acre (inches) GW-Use | ET | Runoff |
|---|---|---|---|---|---|---|---|---|
| **Garcitas Gauge (8164600)** | | | | | | | | |
| 1213 | 24,436 | 78,174 | 7,878 | 84,775 | 2,089 | 3.86 | 41.63 | 1.03 |
| 1214 | 31,002 | 99,181 | 12,941 | 112,904 | 2,525 | 5.01 | 43.70 | 0.98 |
| SUM | 55,438 | 177,355 | 20,819 | 197,679 | 4,614 | 4.51 | 42.79 | 1.00 |
| **Matagorda Bay Gauge (5)** | | | | | | | | |
| 1215 | 18,165 | 58,114 | 4,230 | 57,997 | 1,381 | 2.79 | 37.22 | 0.91 |
| 1216 | 26,901 | 86,060 | 11,478 | 92,712 | 2,432 | 5.12 | 41.36 | 1.09 |
| 1217 | 24,714 | 79,064 | 4,786 | 78,975 | 1,524 | 2.33 | 38.27 | 0.74 |
| 1218 | 13,525 | 43,269 | 1,665 | 40,659 | 1,124 | 1.48 | 36.07 | 1.00 |
| 1219 | 11,079 | 35,445 | 3,313 | 37,113 | 818 | 3.59 | 40.20 | 0.89 |
| 1220 | 5,601 | 17,918 | 3,268 | 22,057 | 367 | 7.00 | 47.26 | 0.79 |
| 1221 | 11,232 | 35,933 | 10,587 | 48,982 | 1,052 | 11.31 | 52.33 | 1.12 |
| 1222 | 4,431 | 14,174 | 11,625 | 33,564 | 825 | 31.48 | 90.92 | 2.23 |
| 1225 | 14,763 | 47,229 | 15,150 | 63,999 | 1,837 | 12.32 | 52.02 | 1.49 |
| 1226 | 18,009 | 57,614 | 35,072 | 116,613 | 1,766 | 23.37 | 77.70 | 1.18 |
| 1227 | 8 | 25 | 4 | 22 | 0 | 6.00 | 33.00 | 0.63 |
| SUM | 148,428 | 474,845 | 101,178 | 592,693 | 13,126 | 8.11 | 47.92 | 1.06 |
| **Victoria Gauge (8176500)** | | | | | | | | |
| 1202 | 232 | 741 | 95 | 861 | 10 | 4.91 | 44.53 | 0.54 |
| 1203 | 2,250 | 7,197 | 1,838 | 10,223 | 86 | 9.80 | 54.52 | 0.46 |
| 1204 | 18,127 | 57,992 | 11,167 | 72,722 | 1,650 | 38.39 | 48.14 | 1.09 |
| 1205 | 19,110 | 61,135 | 15,673 | 83,681 | 1,807 | 9.84 | 52.55 | 1.13 |
| 1206 | 28,469 | 91,075 | 10,905 | 101,704 | 1,900 | 4.60 | 42.87 | 0.80 |
| SUM | 68,188 | 218,140 | 39,678 | 269,191 | 5,453 | 6.98 | 47.37 | 0.96 |
| **Placedo Gauge (8164800)** | | | | | | | | |
| 1223 | 13,135 | 42,022 | 4,150 | 37,792 | 1,303 | 3.79 | 34.53 | 1.19 |
| 1224 | 31,936 | 102,167 | 12,124 | 103,186 | 5,867 | 4.56 | 38.77 | 2.20 |
| SUM | 45,071 | 144,189 | 16,274 | 140,978 | 7,170 | 4.33 | 37.53 | 1.91 |
| **Coleto Gauge (8176900)** | | | | | | | | |
| 1101 | 584 | 1,868 | 385 | 2,403 | 57 | 7.91 | 49.38 | 1.16 |
| 1103 | 2,255 | 7,213 | 1,436 | 9,084 | 189 | 7.64 | 48.34 | 1.00 |
| 1104 | 5,927 | 18,960 | 4,531 | 26,116 | 269 | 9.17 | 52.88 | 0.55 |
| SUM | 8,766 | 28,041 | 6,352 | 37,603 | 515 | 8.69 | 51.48 | 0.70 |
| **McFaddin Gauge (8188570)** | | | | | | | | |
| 722 | 3 | 9 | 19 | 45 | 0 | 76.00 | 76.00 | 1.30 |
| 726 | 465 | 1,486 | 268 | 1,850 | 36 | 6.92 | 47.74 | 0.92 |
| 728 | 320 | 1,025 | 1,675 | 4,156 | 95 | 62.81 | 155.85 | 3.57 |
| 732 | 497 | 1,590 | 2,284 | 5,804 | 185 | 38.59 | 140.14 | 4.46 |
| 734 | 8,869 | 28,372 | 15,490 | 54,670 | 915 | 20.96 | 73.97 | 1.24 |
| 736 | 4,700 | 15,037 | 6,526 | 25,678 | 948 | 16.66 | 65.56 | 2.42 |
| 740 | 39 | 124 | 160 | 419 | 10 | 49.23 | 128.92 | 3.19 |
| SUM | 14,893 | 47,643 | 26,422 | 92,622 | 2,189 | 21.29 | 74.63 | 1.76 |

**Table 9.27 (Cont.)**

| Watershed | Area (acres) | Rainfall (acre-feet) | Watershed Totals (acre-feet) GW-Use | ET | Runoff | Per Acre (inches) GW-Use | ET | Runoff |
|---|---|---|---|---|---|---|---|---|
| **Bloomington Gauge (8187520)** | | | | | | | | |
| 1105 | 13,293 | 42,527 | 6,093 | 49,946 | 1,261 | 5.50 | 45.09 | 1.14 |
| 1108 | 306 | 978 | 31 | 770 | 130 | 1.22 | 30.20 | 5.11 |
| 1109 | 23,209 | 74,248 | 16,671 | 98,514 | 1,676 | 8.62 | 50.94 | 0.87 |
| 1207 | 35,444 | 113,392 | 23,211 | 142,705 | 3,418 | 7.86 | 48.31 | 1.16 |
| 1208 | 41,476 | 132,689 | 50,334 | 209,499 | 4,667 | 14.56 | 60.61 | 1.35 |
| SUM | 113,728 | 363,834 | 96,340 | 501,434 | 11,152 | 10.17 | 52.91 | 1.18 |
| **Tivoli Gauge (8188800)** | | | | | | | | |
| 742 | 765 | 2,449 | 1,480 | 4,936 | 106 | 23.22 | 77.43 | 1.66 |
| 744 | 399 | 1,276 | 1,786 | 4,594 | 165 | 53.71 | 138.16 | 4.97 |
| 746 | 5 | 16 | 24 | 61 | 1 | 57.60 | 146.40 | 1.90 |
| 748 | 5,125 | 16,396 | 14,004 | 40,881 | 595 | 32.79 | 95.92 | 1.39 |
| 750 | 934 | 2,986 | 1,825 | 5,647 | 94 | 23.44 | 72.55 | 1.21 |
| 1110 | 18,137 | 58,024 | 7,493 | 64,671 | 1,356 | 4.96 | 42.79 | 0.90 |
| 1209 | 18,438 | 58,985 | 27,692 | 102,190 | 2,392 | 18.02 | 66.51 | 1.56 |
| 1210 | 28,273 | 90,451 | 39,362 | 155,034 | 2,314 | 16.71 | 65.80 | 0.98 |
| 1212 | 956 | 3,058 | 2,181 | 6,445 | 141 | 27.38 | 81.09 | 1.77 |
| SUM | 73,032 | 233,641 | 95,847 | 384,459 | 7,164 | 15.75 | 63.17 | 1.18 |
| **San Antonio River South of Bloomington (34)** | | | | | | | | |
| 1228 | 23,016 | 73,632 | 6,519 | 64,778 | 2,191 | 3.40 | 33.77 | 1.14 |
| 1229 | 13,807 | 44,172 | 16,654 | 67,988 | 1,310 | 14.43 | 59.09 | 1.14 |
| SUM | 36,823 | 117,804 | 23,173 | 132,766 | 3,501 | 7.55 | 43.27 | 1.14 |
| **County Totals** | | | | | | | | |
| | 564,367 | 1,805,492 | 426,083 | 2,349,425 | 54,884 | 9.06 | 49.95 | 1.17 |

Difference = (No Brush Control value) – (With Brush Control value).

### 9.2.3.5 Effect of Brush Control on Water Balance, 25-Year Averages

Brush control resulted in an overall reduction in ET of 602,810 acre-feet per year when averaged over 25 years (Table 9.28). This reduction was equal to 25.7% of ET without brush control. Reduced groundwater extraction by vegetation accounted for 46% of this reduction in ET. Under the brush control scenario, average annual total ET (including groundwater use) was 1,746,615 acre-feet (Table 9.28), or 96.7% of average annual rainfall. This average of 97% of annual rainfall is very similar to reported values for similar vegetation: 99% for mesquite shurbland in South Texas (Weltz and Blackburn 1995), 97% for mesquite-grassland in the Rolling Plains of Texas (Carlson et al. 1990), 95% for oak-grassland in the Edwards Plateau (Thurow et al. 1988), and 94% for bluestem prairie in Kansas (Bremer et al. 2001). The brush control scenario also resulted in an average of 2,009 acre-feet more runoff per year (Table 9.28).

**Table 9.28 Differences in 25-year average annual water balance components (acre-feet) between no brush control (Scenario 4) and brush control (Scenario 8, 90% of woody species) simulations under the moderate rainfall regime and moderate livestock grazing, Victoria County EDYS model.**

| Watershed | Area | No Brush Control | | | With Brush Control | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (acres) | GW-Use | ET | Runoff | GW-Use | ET | Runoff | GW-Use | ET | Runoff |
| **Garcitas Gauge (8164600)** | | | | | | | | | | |
| 1213 | 24,436 | 7,878 | 84,775 | 2,089 | 2,555 | 70,423 | 2,144 | 5,323 | 14,352 | - 55 |
| 1214 | 31,002 | 12,941 | 112,904 | 2,525 | 5,234 | 93,031 | 2,583 | 7,707 | 19,873 | - 58 |
| SUM | 55,438 | 20,819 | 197,679 | 4,614 | 7,789 | 163,454 | 4,727 | 13,030 | 34,225 | -113 |
| **Matagorda Bay Gauge (5)** | | | | | | | | | | |
| 1215 | 18,165 | 4,230 | 57,997 | 1,381 | 401 | 47,615 | 1,417 | 3,829 | 10,382 | - 36 |
| 1216 | 26,901 | 11,478 | 92,712 | 2,432 | 2,651 | 73,649 | 2,527 | 8,827 | 19,063 | - 95 |
| 1217 | 24,714 | 4,786 | 78,975 | 1,524 | 1,795 | 69,299 | 1,572 | 2,991 | 9,676 | - 48 |
| 1218 | 13,525 | 1,665 | 40,659 | 1,124 | 598 | 37,138 | 1,151 | 1,067 | 3,521 | - 27 |
| 1219 | 11,079 | 3,313 | 37,113 | 818 | 1,588 | 33,118 | 798 | 1,725 | 3,995 | 20 |
| 1220 | 5,601 | 3,268 | 22,057 | 367 | 896 | 16,899 | 377 | 2,372 | 5,158 | - 10 |
| 1221 | 11,232 | 10,587 | 48,982 | 1,052 | 3,223 | 34,369 | 1,081 | 7,364 | 14,613 | - 29 |
| 1222 | 4,431 | 11,625 | 33,564 | 825 | 5,493 | 20,929 | 878 | 6,132 | 12,635 | - 53 |
| 1225 | 14,763 | 15,150 | 63,999 | 1,837 | 4,864 | 44,645 | 1,836 | 10,286 | 19,354 | 1 |
| 1226 | 18,009 | 35,072 | 116,613 | 1,766 | 11,291 | 67,912 | 1,842 | 23,781 | 48,701 | - 76 |
| 1227 | 8 | 4 | 22 | 0 | 3 | 18 | 0 | 1 | 4 | 0 |
| SUM | 148,428 | 101,178 | 592,693 | 13,126 | 32,803 | 445,591 | 13,479 | 68,375 | 147,102 | -353 |
| **Victoria Gauge (8176500)** | | | | | | | | | | |
| 1202 | 232 | 95 | 861 | 10 | 36 | 712 | 11 | 59 | 149 | - 1 |
| 1203 | 2,250 | 1,838 | 10,223 | 86 | 567 | 7,538 | 86 | 1,271 | 2,685 | 0 |
| 1204 | 18,127 | 11,167 | 72,722 | 1,650 | 3,585 | 56,474 | 1,680 | 7,582 | 16,248 | - 30 |
| 1205 | 19,110 | 15,673 | 83,681 | 1,807 | 3,481 | 57,705 | 1,878 | 12,192 | 25,976 | - 71 |
| 1206 | 28,469 | 10,905 | 101,704 | 1,900 | 1,942 | 79,261 | 2,007 | 8,963 | 22,443 | -107 |
| SUM | 68,188 | 39,678 | 269,191 | 5,453 | 9,611 | 201,690 | 5,662 | 30,067 | 67,501 | -209 |
| **Placedo Gauge (8164800)** | | | | | | | | | | |
| 1223 | 13,135 | 4,150 | 37,792 | 1,303 | 683 | 32,321 | 1,280 | 3,467 | 5,471 | 23 |
| 1224 | 31,936 | 12,124 | 103,186 | 5,867 | 2,218 | 84,223 | 5,916 | 9,906 | 18,963 | - 49 |
| SUM | 45,071 | 16,274 | 140,978 | 7,170 | 2,901 | 116,544 | 7,196 | 13,373 | 24,434 | - 26 |
| **Coleto Gauge (8176900)** | | | | | | | | | | |
| 1101 | 584 | 385 | 2,403 | 57 | 334 | 2,259 | 58 | 51 | 144 | - 1 |
| 1103 | 2,255 | 1,436 | 9,084 | 189 | 1,023 | 8,154 | 193 | 413 | 930 | - 4 |
| 1104 | 5,927 | 4,531 | 26,116 | 269 | 2,183 | 20,879 | 283 | 2,348 | 5,237 | - 14 |
| SUM | 8,766 | 6,352 | 37,603 | 515 | 3,540 | 31,292 | 534 | 2,812 | 6,311 | - 19 |
| **McFaddin Gauge (8188570)** | | | | | | | | | | |
| 722 | 3 | 19 | 45 | 0 | 5 | 16 | 0 | 14 | 29 | 0 |
| 726 | 465 | 268 | 1,850 | 36 | 73 | 1,397 | 41 | 195 | 453 | - 5 |
| 728 | 320 | 1,675 | 4,156 | 95 | 465 | 1,668 | 111 | 1,210 | 2,488 | - 16 |
| 732 | 497 | 2,284 | 5,804 | 185 | 720 | 2,582 | 204 | 1,564 | 3,222 | - 19 |
| 734 | 8,869 | 15,490 | 54,670 | 915 | 4,943 | 32,369 | 1,000 | 10,547 | 22,301 | - 85 |
| 736 | 4,700 | 6,526 | 25,678 | 948 | 2,121 | 16,378 | 1,052 | 4,405 | 9,300 | -104 |
| 740 | 39 | 160 | 419 | 10 | 57 | 208 | 11 | 103 | 211 | - 1 |
| SUM | 14,893 | 26,422 | 92,622 | 2,189 | 8,384 | 54,618 | 2,419 | 18,038 | 38,004 | -230 |

**Table 9.28 (Cont.)**

| Watershed | Area | No Brush Control | | | With Brush Control | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (acres) | GW-Use | ET | Runoff | GW-Use | ET | Runoff | GW-Use | ET | Runoff |
| **Bloomington Gauge (8187520)** | | | | | | | | | | |
| 1105 | 13,293 | 6,093 | 49,946 | 1,261 | 2,184 | 41,139 | 1,284 | 3,909 | 8,807 | - 23 |
| 1108 | 306 | 31 | 770 | 130 | 13 | 731 | 130 | 18 | 39 | 0 |
| 1109 | 23,209 | 16,671 | 98,514 | 1,676 | 5,101 | 72,680 | 1,780 | 11,570 | 25,834 | -104 |
| 1207 | 35,444 | 23,211 | 142,705 | 3,418 | 5,433 | 102,598 | 3,552 | 17,778 | 40,107 | -134 |
| 1208 | 41,476 | 50,334 | 209,499 | 4,667 | 16,738 | 138,253 | 4,936 | 33,596 | 71,246 | -269 |
| SUM | 113,728 | 96,340 | 501,434 | 11,152 | 29,469 | 355,401 | 11,682 | 66,871 | 146,033 | -530 |
| **Tivoli Gauge (8188800)** | | | | | | | | | | |
| 742 | 765 | 1,480 | 4,936 | 106 | 690 | 3,290 | 114 | 790 | 1,646 | - 8 |
| 744 | 399 | 1,786 | 4,594 | 165 | 604 | 2,174 | 179 | 1,182 | 2,420 | - 14 |
| 746 | 5 | 24 | 61 | 1 | 8 | 28 | 1 | 16 | 33 | 0 |
| 748 | 5,125 | 14,004 | 40,881 | 595 | 7,449 | 27,674 | 616 | 6,555 | 13,207 | - 21 |
| 750 | 934 | 1,825 | 5,647 | 94 | 1,072 | 4,250 | 89 | 753 | 1,397 | 5 |
| 1110 | 18,137 | 7,493 | 64,671 | 1,356 | 575 | 48,985 | 1,544 | 6,918 | 15,686 | -188 |
| 1209 | 18,438 | 27,692 | 102,190 | 2,392 | 11,804 | 68,052 | 2,508 | 15,888 | 34,138 | -116 |
| 1210 | 28,273 | 39,362 | 155,034 | 2,314 | 18,208 | 109,926 | 2,514 | 21,154 | 45,108 | -200 |
| 1212 | 956 | 2,181 | 6,445 | 141 | 1,283 | 4,751 | 136 | 898 | 1,694 | 5 |
| SUM | 73,032 | 95,847 | 384,459 | 7,164 | 41,693 | 269,130 | 7,701 | 54,154 | 115,329 | -537 |
| **San Antonio River South of Bloomington (34)** | | | | | | | | | | |
| 1228 | 23,016 | 6,519 | 64,778 | 2,191 | 2,515 | 59,610 | 2,155 | 4,004 | 5,168 | 36 |
| 1229 | 13,807 | 16,654 | 67,988 | 1,310 | 7,483 | 49,285 | 1,338 | 9,171 | 18,703 | - 28 |
| SUM | 36,823 | 23,173 | 132,766 | 3,501 | 9,998 | 108,895 | 3,493 | 13,175 | 23,871 | 8 |
| **County Totals** | | | | | | | | | | |
| | 564,367 | 426,083 | 2,349,425 | 54,884 | 146,188 | 1,746,615 | 56,893 | 279,895 | 602,810 | -2009 |

### 9.2.3.6 Maximum Potential Water Yield Enhancement, 25-Year Average Basis

Potential enhancement of water yield from this brush control scenario (90% removal of woody species, except only 50% of live oak, average rainfall regime, and moderate stocking rate of cattle) for the entire county was an annual average of 604,819 acre-feet, or 12.86 inches per acre (Table 9.29). Eight of the 46 watersheds (18%) had potential increased average annual yields of less than 6 inches per acre, 14 (30%) between 6-12 inches, 14 (30%) between 12-24 inches, 5 (11%) between 24-36 inches, and 5 (11%) more than 36 inches per year. Watersheds with higher potential yields were concentrated in the southern part of the county (e.g., McFaddin Gauge watersheds = 30.8 inches annual mean; Table 9.29) and those with lower potential yields were concentrated in the north and northwest areas (Fig. 9.8).

**Table 9.29 Maximum potential annual (25-year averages) water yield enhancement and decrease in groundwater use by vegetation (GW-Use) resulting from the maximum brush control scenario using the Victoria County EDYS model. ET values are average annual decreases and runoff values are average annual increases (net yield = decreased ET + increased runoff).**

| Watershed | Area (acres) | Enhanced Yield (acre-feet) ET | Runoff | Net Yield | Per Acre Basis (inches/acre) | Decrease in GW-Use[1] (acre-feet) | (inches/acre) |
|---|---|---|---|---|---|---|---|
| **Garctias Gauge (8164600)** | | | | | | | |
| 1213 | 24,436 | 14,352 | 55 | 14,407 | 7.07 | 5,323 | 2.61 |
| 1214 | 31,002 | 19,873 | 58 | 19,931 | 7.71 | 7,707 | 2.98 |
| SUM | 55,438 | 34,225 | 113 | 34,338 | 7.43 | 13,030 | 2.82 |
| **Matagorda Bay Gauge (5)** | | | | | | | |
| 1215 | 18,165 | 10,382 | 36 | 10,418 | 6.89 | 3,829 | 2.53 |
| 1216 | 26,901 | 19,063 | 95 | 19,158 | 8.55 | 8,827 | 3.94 |
| 1217 | 24,714 | 9,676 | 48 | 9,724 | 4.72 | 2,991 | 1.45 |
| 1218 | 13,525 | 3,521 | 27 | 3,548 | 3.15 | 1,067 | 0.95 |
| 1219 | 11,079 | 3,995 | - 20 | 3,975 | 4.35 | 1,725 | 1.87 |
| 1220 | 5,601 | 5,158 | 10 | 5,168 | 11.07 | 2,372 | 5.08 |
| 1221 | 11,232 | 14,613 | 29 | 14,642 | 15.64 | 7,364 | 7.87 |
| 1222 | 4,431 | 12,635 | 53 | 12,688 | 34.36 | 6,132 | 16.61 |
| 1225 | 14,763 | 19,354 | - 1 | 19,353 | 22.50 | 10,286 | 8.36 |
| 1226 | 18,009 | 48,701 | 76 | 48,777 | 12.02 | 23,781 | 15.85 |
| 1227 | 8 | 4 | 0 | 4 | 6.00 | 1 | 1.50 |
| SUM | 148,428 | 147,102 | 353 | 147,455 | 11.92 | 68,375 | 5.53 |
| **Victoria Gauge (8176500)** | | | | | | | |
| 1202 | 232 | 149 | 1 | 150 | 7.76 | 59 | 3.05 |
| 1203 | 2,250 | 2,685 | 0 | 2,685 | 14.32 | 1,271 | 6.78 |
| 1204 | 18,127 | 16,248 | 30 | 16,278 | 10.78 | 7,582 | 5.02 |
| 1205 | 19,110 | 25,976 | 71 | 26,047 | 12.03 | 12,192 | 7.66 |
| 1206 | 28,469 | 22,443 | 107 | 22,550 | 9.51 | 8,963 | 3.78 |
| SUM | 68,188 | 67,501 | 209 | 67,710 | 11.92 | 30,067 | 5.29 |
| **Placedo Gauge (8164800)** | | | | | | | |
| 1223 | 13,135 | 5,471 | - 23 | 5,448 | 4.98 | 3,467 | 3.17 |
| 1224 | 31,936 | 18,963 | 49 | 19,012 | 7.14 | 9,906 | 3.72 |
| SUM | 45,071 | 24,434 | 26 | 24,460 | 6.51 | 13,373 | 3.56 |
| **Coleto Gauge (8176900)** | | | | | | | |
| 1101 | 584 | 144 | 1 | 145 | 2.98 | 51 | 1.05 |
| 1103 | 2,255 | 930 | 4 | 934 | 4.97 | 413 | 2.20 |
| 1104 | 5,927 | 5,237 | 14 | 5,251 | 10.63 | 2,348 | 4.75 |
| SUM | 8,766 | 6,311 | 19 | 6,330 | 8.67 | 2,812 | 3.85 |
| **McFaddin Gauge (8188570)** | | | | | | | |
| 722 | 3 | 29 | 0 | 29 | 116.00 | 14 | 56.00 |
| 726 | 465 | 453 | 5 | 458 | 11.84 | 195 | 5.03 |
| 728 | 320 | 2,488 | 16 | 2,504 | 93.90 | 1,210 | 45.38 |
| 732 | 497 | 3,222 | 19 | 3,241 | 78.25 | 1,564 | 37.76 |
| 734 | 8,869 | 22,301 | 85 | 22,386 | 30.29 | 10,547 | 13.14 |
| 736 | 4,700 | 9,300 | 104 | 9,404 | 24.01 | 4,405 | 11.25 |
| 740 | 39 | 211 | 1 | 212 | 65.23 | 103 | 31.69 |
| SUM | 14,893 | 38,004 | 230 | 38,234 | 30.81 | 18,038 | 14.54 |

**Table 9.29 (Cont.)**

| Watershed | Area | Enhanced Yield (acre-feet) ET | Runoff | Net Yield | Per Acre Basis (inches/acre) | Decrease in GW-Use[1] (acre-feet) | (inches/acre) |
|---|---|---|---|---|---|---|---|
| **Bloomington Gauge (8187520)** | | | | | | | |
| 1105 | 13,293 | 8,807 | 23 | 8,830 | 7.97 | 3,909 | 3.52 |
| 1108 | 306 | 39 | 0 | 39 | 1.53 | 18 | 0.71 |
| 1109 | 23,209 | 25,834 | 104 | 25,938 | 13.41 | 11,570 | 5.98 |
| 1207 | 35,444 | 40,107 | 134 | 40,241 | 13.62 | 17,778 | 6.02 |
| 1208 | 41,476 | 71,246 | 269 | 71,515 | 20.69 | 33,596 | 9.72 |
| SUM | 113,728 | 146,033 | 530 | 146,563 | 15.47 | 66,871 | 7.06 |
| **Tivoli Gauge (8188800)** | | | | | | | |
| 742 | 765 | 1,646 | 8 | 1,654 | 25.94 | 790 | 12.39 |
| 744 | 399 | 2,420 | 14 | 2,434 | 12.07 | 1,182 | 35.55 |
| 746 | 5 | 33 | 0 | 33 | 79.20 | 16 | 38.40 |
| 748 | 5,125 | 13,207 | 21 | 13,228 | 30.97 | 6,555 | 15.35 |
| 750 | 934 | 1,397 | - 5 | 1,392 | 17.88 | 753 | 9.67 |
| 1110 | 18,137 | 15,686 | 188 | 15,874 | 10.50 | 6,918 | 4.57 |
| 1209 | 18,438 | 34,138 | 116 | 34,254 | 22.29 | 15,888 | 10.34 |
| 1210 | 28,273 | 45,108 | 200 | 45,308 | 19.23 | 21,154 | 8.98 |
| 1212 | 956 | 1,694 | - 5 | 1,689 | 21.20 | 898 | 11.27 |
| SUM | 73,032 | 115,329 | 537 | 115,866 | 19.04 | 54,154 | 8.90 |
| **San Antonio River South of Bloomington (34)** | | | | | | | |
| 1228 | 23,016 | 5,168 | - 36 | 5,132 | 2.67 | 4,004 | 2.09 |
| 1229 | 13,807 | 18,703 | 28 | 18,731 | 16.28 | 9,171 | 7.97 |
| SUM | 36,823 | 23,871 | - 8 | 23,863 | 7.78 | 13,175 | 4.29 |
| **County Totals** | | | | | | | |
| | 564,367 | 602,810 | 2,009 | 604,819 | 12.86 | 279,895 | 5.95 |

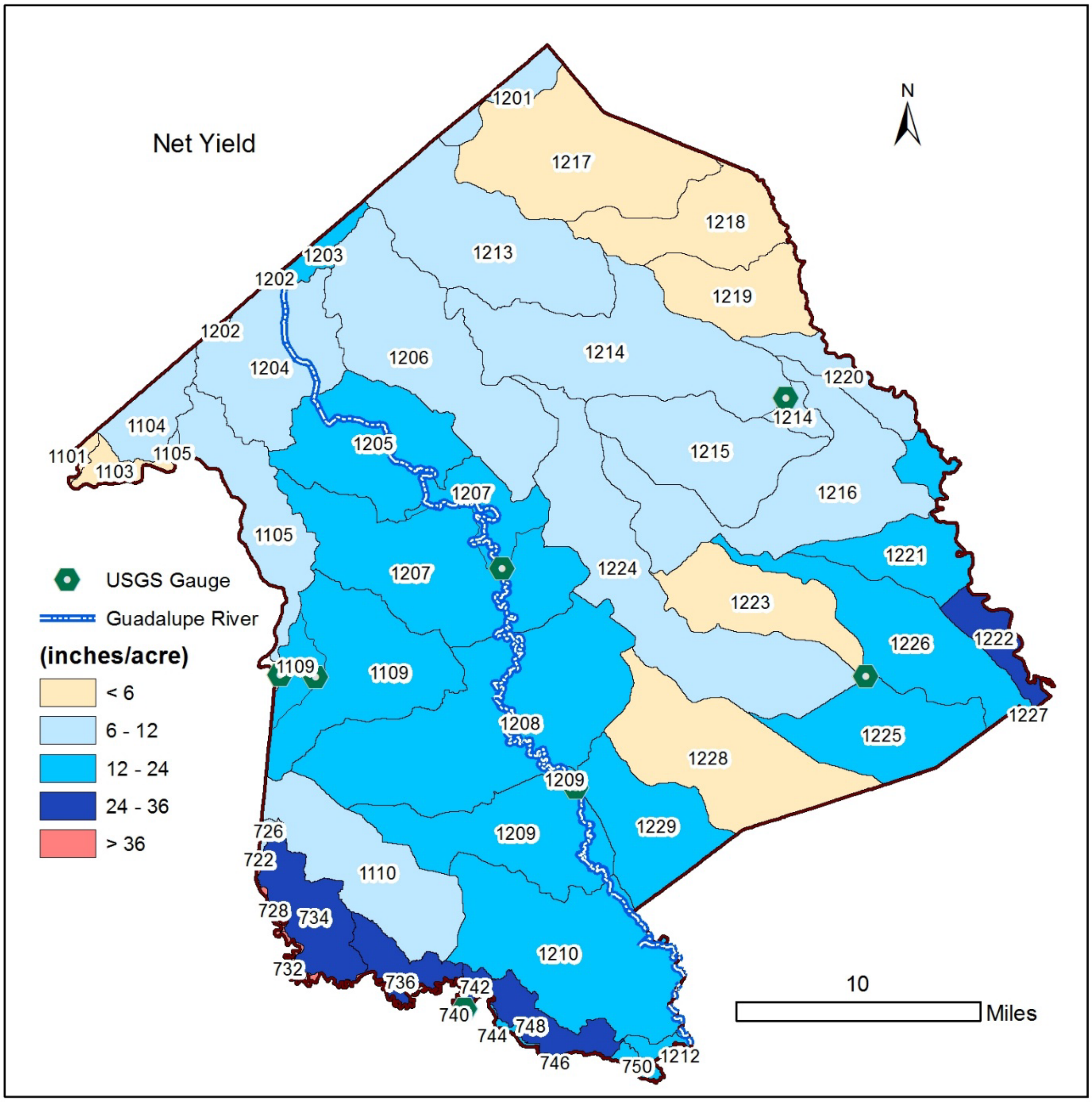


**Figure 9.8 Maximum potential increased annual water yield (inches/acre) from brush control based on 25-year simulations of the Victoria EDYS model using the moderate rainfall regime.**

Potential increase in water yield from brush control is the result of two primary factors: 1) decreased ET because of less, and different types of, vegetation and 2) lower groundwater use because of a reduction in amount of deep-rooted woody species. Overall, brush control reduced groundwater use by an average of 279,895 acre-feet per year (25-year average), or 5.95 inches per acre per year. As with enhanced water yield overall, reduction in groundwater use varied considerably among watersheds (Fig. 9.9).

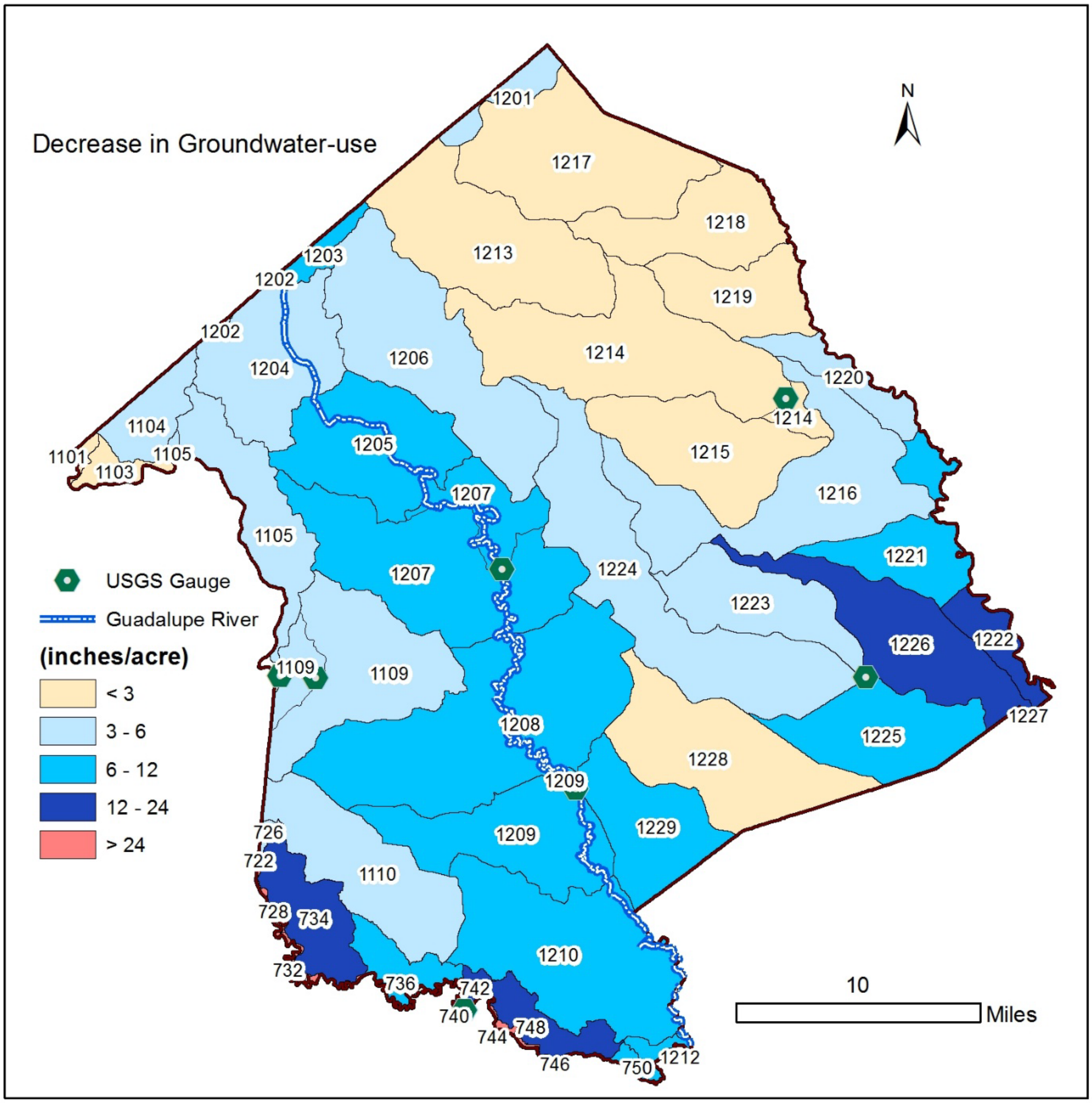


**Figure 9.9 Decrease in annual groundwater use by vegetation (inches/acre) from maximum brush control based on 25-year simulations of the Victoria EDYS model using the moderate rainfall regime.**

## 10.0 UNCERTAINTY

As with all mathematical representations of physical and biological systems, the EDYS model approximates the processes that affect the movement of water through a watershed while interacting with soils, vegetation, and animals.

Rainfall events drive the hydrological processes. Rainfall datasets are limited by the locations of rain gauges relative to the model domain, as well as the continuity and length of their periods of record. Any uncertainties in the rainfall data transfer directly to the model's hydrological outputs of runoff, infiltration, evapotranspiration, and storage within a watershed. As point observations, the rainfall values over time must be distributed across the modeled area. Typical approaches include Thiessen polygons, isohyetal contour maps, and selections based on topographic and geographic characteristics of the area of interests. The natural variabilities of storm intensities and areal distributions are impossible to capture precisely for each storm, so the user must accept the approximations. Application of isohyetal precipitation contour maps is done often for simulation of individual flooding events, but is rarely employed for long-term simulations as in the typical EDYS projects.

Daily time steps are applied in EDYS simulations as all the different processes are represented in the same time frame. For large models, shorter time steps make run times untenable. Most real storm durations are less than one day, but some storms can last from part of one day to the next. Runoff generation depends on both the intensity and duration of the storm event, as well as the antecedent soil moisture conditions. EDYS does track the soil moisture storage day to day. The day's rainfall is broken up into five timed segments within the day to facilitate infiltration into the underlying soil layers. Real storms vary randomly in their intensity over the events, so this uncertainty is inherent in the EDYS applications. Past applications of EDYS (for example, McLendon and Coldren 2005) demonstrated that EDYS outputs are most useful for cumulative water volumes over long time periods rather than point values at a single point in time.

Computer resource limitations have restricted the ecological heterogeneity that can be simulated in a large-scale EDYS application like Victoria County, as evidenced in the discussions above on plot-type proliferation. One consequence is the use of a single soil type for each plot-type in the model. Instead of using all soil types that occur in each plot type, the model inputs were set to use only the most common soil type based on cell counts, introducing uncertainty in those areas where the most common soil type was substituted for the lesser common soils. The degree of uncertainty depends on the magnitude of differences between the soils and the extent of the replaced soil type. Spatial distribution of soil types is based on NRCS soil mapping, and any uncertainty inherent in the mapping process is propagated through the EDYS model. Additionally, soil characteristics for a single soil series will differ slightly between areas across the domain, based on past vegetation and land use changes. These are unknown and impossible to accurately represent. Thus, watershed aggregates and averages for vegetation and hydrological values reflect all of these uncertainties deriving from soil types. While EDYS is structured to allow greater heterogeneity in soils, limitations in computer resources (like storage capacity and run times) have not allowed that capability to be fully implemented.

The grid cell spatial distribution applied in EDYS was selected to allow discrete variations in vegetation, soil, and animal parameters and variables. This approach also allows the hydrologic variables, such as precipitation, to be varied cell-by-cell if desired by the user. The grid cell approach supports the unique abilities of EDYS to distribute vegetation types and simulate their changes over growing seasons and longer time periods, as well as to estimate the associated evapotranspiration. The pertinent vegetation parameters have been gathered from detailed literature searches and compiled by the EDYS team over many years. Application of those cited values brings along any uncertainties from the studies that generated them. Identification of vegetation distributions is done by detailed evaluation of aerial imagery and confirmed by site visits. The EDYS team is experienced in plant identification and continues to update the literature database over time.

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# APPENDIX A PRECIPITATION DATA

Appendix Table A.1 Annual precipitation (PPT; inches) data for Victoria, Texas, 1893-2017.

| Year | PPT | Year | PPT | Year | PPT | Year | PPT | Year | PPT | Year | PPT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1893 | 19.22 |
| | | | | | | | | | | 1894 | 31.60 |
| | | | | | | | | | | 1895 | ----- |
| | | | | | | | | | | 1896 | ----- |
| | | | | | | | | | | 1897 | ----- |
| | | | | | | | | | | 1898 | 25.75 |
| | | | | | | | | | | 1899 | 36.86 |
| | | | | | | | | | | SUM | 113.43 |
| | | | | | | | | | | **MEAN** | **28.36** |
| 1900 | 53.68 | 1910 | 30.22 | 1920 | 28.36 | 1930 | 37.15 | 1940 | 35.65 | 1950 | 18.11 |
| 1901 | 23.00 | 1911 | 36.42 | 1921 | 39.82 | 1931 | 44.30 | 1941 | 51.00 | 1951 | 29.74 |
| 1902 | 32.00 | 1912 | 23.99 | 1922 | 33.92 | 1932 | 30.32 | 1942 | 38.32 | 1952 | 34.91 |
| 1903 | 44.44 | 1913 | 41.18 | 1923 | 44.65 | 1933 | 35.16 | 1943 | 37.54 | 1953 | 22.97 |
| 1904 | 33.93 | 1914 | 51.35 | 1924 | 29.52 | 1934 | 38.54 | 1944 | 43.46 | 1954 | 19.85 |
| 1905 | 45.30 | 1915 | 25.73 | 1925 | 27.14 | 1935 | 37.28 | 1945 | 27.04 | 1955 | 24.86 |
| 1906 | 26.99 | 1916 | 26.57 | 1926 | 40.99 | 1936 | 46.67 | 1946 | 34.45 | 1956 | 17.94 |
| 1907 | 43.98 | 1917 | 11.15 | 1927 | 24.41 | 1937 | 25.51 | 1947 | 34.63 | 1957 | 47.52 |
| 1908 | 40.17 | 1918 | 36.36 | 1928 | 30.57 | 1938 | 32.24 | 1948 | 25.75 | 1958 | 40.98 |
| 1909 | 32.82 | 1919 | 59.53 | 1929 | 51.76 | 1939 | 20.57 | 1949 | 39.52 | 1959 | 35.20 |
| SUM | 376.31 | SUM | 342.50 | SUM | 351.14 | SUM | 347.74 | SUM | 367.36 | SUM | 292.08 |
| **MEAN** | **37.63** | **MEAN** | **34.25** | **MEAN** | **35.11** | **MEAN** | **34.77** | **MEAN** | **36.74** | **MEAN** | **29.21** |
| 1960 | 50.24 | 1970 | 39.78 | 1980 | 32.54 | 1990 | 35.77 | 2000 | 36.76 | 2010 | 46.62 |
| 1961 | 36.13 | 1971 | 36.06 | 1981 | 45.10 | 1991 | 56.72 | 2001 | 42.77 | 2011 | 13.08 |
| 1962 | 25.89 | 1972 | 42.41 | 1982 | 32.53 | 1992 | 51.38 | 2002 | 39.13 | 2012 | 28.13 |
| 1963 | 22.05 | 1973 | 45.65 | 1983 | 42.41 | 1993 | 51.40 | 2003 | 38.67 | 2013 | 25.56 |
| 1964 | 33.32 | 1974 | 43.34 | 1984 | 33.92 | 1994 | 43.67 | 2004 | 73.65 | 2014 | 30.19 |
| 1965 | 30.85 | 1975 | 36.96 | 1985 | 39.99 | 1995 | 33.47 | 2005 | 34.93 | 2015 | 53.68 |
| 1966 | 35.47 | 1976 | 43.25 | 1986 | 39.19 | 1996 | 28.74 | 2006 | 39.44 | 2016 | 39.25 |
| 1967 | 33.90 | 1977 | 39.21 | 1987 | 43.09 | 1997 | 67.18 | 2007 | 71.76 | 2017 | 41.31 |
| 1968 | 49.32 | 1978 | 43.08 | 1988 | 15.91 | 1998 | 46.39 | 2008 | 21.71 | | |
| 1969 | 44.64 | 1979 | 49.30 | 1989 | 25.79 | 1999 | 27.01 | 2009 | 30.78 | | |
| SUM | 361.81 | SUM | 419.04 | SUM | 350.47 | SUM | 441.73 | SUM | 429.60 | SUM | 277.82 |
| **MEAN** | **36.18** | **MEAN** | **41.90** | **MEAN** | **35.05** | **MEAN** | **44.17** | **MEAN** | **42.96** | **MEAN** | **34.73** |

Overall mean (1893-2017, excluding incomplete years) = 36.65 inches

Incomplete years, indicated by (-----), are years for which some data exist, but are missing data for one or more months.
Station data: 1893-1946 (CP&L 419365); 1947-1960 (Victoria 12922); 1961 (Victoria 12922 Jan-Jun, Victoria Airport 12912 Jul-Dec); 1962-2016 Victoria Airport (12912).

# APPENDIX B SOILS

**Appendix Table B.1 Soil units occurring in Victoria County (Miller 1982) and corresponding composite units used in the Victoria County EDYS model.**

| Symbol | NRCS Soil Unit | EDYS Soil Unit |
|---|---|---|
| Ar | Aransas clay, frequently flooded | Aransas clay |
| Au | Austwell clay, frequently flooded | Aransas clay |
| DaA | Dacosta sandy clay loam, 0-1% slopes | Lake Charles clay |
| DaB | Dacosta sandy clay loam, 1-3% slopes | Lake Charles clay |
| DnA | Dacosta-Contee complex, 0-1% slopes | Lake Charles clay |
| DuB | Dacosta-Urban land complex, 0-3% slopes | Lake Charles clay |
| DvC | Dacosta and Telferner soils, 2-5% slopes | Lake Charles clay |
| Dw | Degola sandy clay loam, frequently flooded | Meguin silty clay |
| DxB | Denhawken-Elemendorf complex, 0-2% slopes | Denhawken-Elemndorf clay loam |
| EdA | Edna fine sandy loam, 0-1% slopes | Nada-Cieno sandy loam |
| EdB | Edna fine sandy loam, 1-3% slopes | Nada-Cieno sandy loam |
| FaA | Faddin fine sandy loam, 0-1% slopes | Telferner fine sandy loam |
| FaB | Faddin fine sandy loam, 1-3% slopes | Telferner fine sandy loam |
| FaC | Faddin fine sandy loam, 3-5% slopes | Telferner fine sandy loam |
| FoB | Fordtran loamy fine sand, 0-3% slopes | Fordtran loamy fine sand |
| GaC | Garcitas gravelly loamy fine sand, 1-5% slopes | Inez fine sandy loam |
| GdC | Goldmire very gravelly loamy fine sand, 1-5% slopes | Tremona gravelly loamy sand |
| InB | Inez fine sandy loam, 0-2% slopes | Inez fine sandy loam |
| KyC | Kuy loamy sand, 1-5% slopes | Kuy loamy sand |
| LaA | Lake Charles clay, 0-1% slopes | Lake Charles clay |
| LaB | Lake Charles clay, 1-3% slopes | Lake Charles clay |
| LaD | Lake Charles clay, 5-8% slopes | Lake Charles clay |
| LcB | Lake Charles-Urban land complex, 0-3% slopes | Lake Charles clay |
| LmB | Leming loamy fine sand, 0-3% slopes | Leming loamy fine sand |
| Me | Meguin silty clay, occasionally flooded | Meguin silty clay |
| Mf | Meguin silty clay, frequently flooded | Meguin silty clay |
| NcA | Nada-Cieno complex, 0-1% slopes | Nada-Cienco sandy loam |
| PaB | Papalote fine sandy loam, 1-3% slopes | Papalote fine sandy loam |
| Pe | Placedo silty clay loam, frequently flooded | Placedo silty clay loam |
| RaB | Runge fine sandy loam, 0-2% slopes | Runge fine sandy loam |
| RaC | Runge fine sandy loam, 2-5% slopes | Runge fine sandy loam |
| RbC | Rupley fine sand, 1-5% slopes | Kuy loamy sand |
| Rd | Rydolph silty clay, occasionally flooded | Meguin silty clay |
| Rf | Rydolph silty clay, frequently flooded | Meguin silty clay |
| SaB | Sarnosa loam, 1-3% slopes | Sarnosa loam |
| SkC | Silvern very gravelly loamy sand, 1-5% slopes | Termona gravelly loamy sand |
| Sn | Sinton loam, occasionally flooded | Meguin silty clay |
| StB | Straber loamy fine sand, 0-2% slopes | Inez fine sandy loam |
| StC | Straber loamy fine sand, 2-5% slopes | Inez fine sandy loam |
| TeA | Telferner fine sandy loam, 0-1% slopes | Telferner fine sandy loam |
| TeB | Telferner fine sandy loam, 1-3% slopes | Telferner fine sandy loam |
| TfB | Telferner-Urban land complex, 0-3% slopes | Telferner fine sandy loam |
| TgC | Tremona gravelly loamy sand, 1-3% slopes | Tremona gravelly loamy sand |
| To | Trinity clay, occasionally flooded | Trinity clay |
| Tr | Trinity clay, frequently flooded | Trinity clay |
| VaD | Valco clay loam, 2-8% slopes | Valco clay loam |
| WeB | Weesatche sandy clay loam, 1-3% slopes | Weesatche sandy clay loam |
| WeC | Weesatche sandy clay loam, 3-5% slopes | Weesatche sandy clay loam |
| Za | Zalco fine sand, frequently flooded | Zalco sand |

# APPENDIX C VEGETATION

Appendix Table C.1 NRCS range sites, associated soils, and corresponding EDYS plant communities (mid-seral) used in the Victoria County EDYS model.

| Range Site | Soils | EDYS Plant Community |
|---|---|---|
| Blackland | DaA DaB DnA DuB DvC LaA LaB LaD LcB | huisache-little bluestem-buffalograss |
| Clay loam | WeB WeC | huisache-little bluestem-ragweed |
| Clayey bottomland | To Tr | hackberry-live oak-Johnsongrass |
| Claypan prairie | EdA EdB NcA | Macartney rose-little bluestem-knotroot bristlegrass |
| Deep sand | KyC RbC | live oak-seacoast bluestem-balsamscale |
| Gravelly | GdC SkC TgC | mesquite-little bluestem-silver bluestem |
| Gray sandy loam | SaB | huisache-buffalograss-hooded windmill |
| Loamy bottomland | Dw Me Mf Rd Rf Sn | live oak-hackberry-brownseed paspalum |
| Loamy prairie | FaA FaB FaC TeA TeB TfB | mesquite-little bluestem-brownseed paspalum |
| Loamy sand | LmB PaB RaB RaC RaC2 | live oak-little bluestem-thin paspalum |
| Rolling blackland | DxB | huisache-buffalograss-Texas wintergrass |
| Salt marsh | Pe | gulf cordgrass-saltgrass-sea oxeye |
| Salty bottomland | Ar Au | huisache-gulf cordgrass-saltgrass |
| Sandy bottomland | Za | live oak-little bluestem-knotroot bristlegrass |
| Sandy loam | GaC InB StB StC | mesquite-little bluestem-balsamscale |
| Sandy loam | RaB RaC | mesquite-little bluestem-balsamscale |
| Sandy prairie | FoB | mesquite-little bluestem-arrowfeather threeawn |
| Shallow | VaD | blackbrush-silver bluestem-buffalograss |
| Tight sandy loam | PaB | mesquite-little bluestem-purple threeawn |

**Determination of species composition and initial biomass (Appendix Table C.2)**

In Appendix Table C.2, species composition under light grazing (late-seral conditions) was taken from data in Appendix Tables C.3-C.6. Species composition under moderate (mid-seral) grazing was based on data from Appendix Tables C.7-C.18.

Total grass aboveground biomass under mid-seral conditions was estimated at 70% of late-seral levels (Appendix Table C.22) and total forb aboveground biomass was estimated at 38% of grass levels (Box 1961, Powell and Box 1967, Box and White 1969, Smeins and Diamond 1983, McLendon and Finch unpublished data, McLendon 2014, 2015; Appendix Tables C.7-C.11).

For woody species, the values are relative composition (%) of woody plant cover. Herbaceous standing crop biomass is decreased as woody plant cover increases, using the relationship:

amount = (amount at 0% woody cover)[(1.00 – 0.8(% woody cover)]

based on data from Appendix Table C.24.

Appendix Table C.2 Adjustment of plant species composition to account for level of livestock grazing in plant communities in Victoria County. Amounts are clippable biomass (g/m$^2$) for herbaceous species and relative cover for woody species. Late-seral biomass taken from Appendix Table C.3. Mid-seral total grass biomass = 70% of late-seral (Appendix Table C.22).

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Blackland** | | | | | | | | |
| | huisache | 37 | big bluestem | 40 | 4 | ragweed | -- | 80 |
| | hackberry | 2 | bushy bluestem | -- | 28 | wild indigo | 9 | 36 |
| | mesquite | 20 | purple threeawn | -- | 43 | old-mans beard | -- | 10 |
| | live oak | 1 | silver bluestem | -- | 28 | bundleflower | 9 | 5 |
| | baccharis | 8 | sideoats grama | 81 | 8 | sunflower | -- | 20 |
| | Macartn rose | 25 | buffalograss | 20 | 80 | coneflower | 8 | 4 |
| | greenbriar | 5 | bermudagrass | -- | 20 | frogfruit | -- | 20 |
| | prickly pear | 2 | Virginia wildrye | 24 | 12 | bush sunflower | 9 | 36 |
| | | | switchgrass | 40 | 6 | | | |
| | | | longtom | 24 | 23 | | | |
| | | | brownseed paspalum | 48 | 36 | | | |
| | | | thin paspalum | -- | 40 | | | |
| | | | little bluestem | 363 | 72 | | | |
| | | | knotroot bristle | 24 | 30 | | | |
| | | | plains bristle | -- | 6 | | | |
| | | | indiangrass | 81 | 4 | | | |
| | | | Johnsongrass | -- | 14 | | | |
| | | | tall dropseed | 24 | 8 | | | |
| | | | smutgrass | -- | 56 | | | |
| | | | Texas wintergrass | 24 | 17 | | | |
| | | | Flatsedge | -- | 20 | | | |
| | | | Total grasses | 793 | 555 | Total forbs | 35 | 211 |
| **Clayey Bottomland** | | | | | | | | |
| | huisache | 5 | big bluestem | 65 | 4 | ragweed | 6 | 12 |
| | pecan | 15 | bushy bluestem | 2 | 29 | giant ragweed | -- | 40 |
| | hackberry | 20 | silver bluestem | 26 | 30 | spiny aster | 12 | 6 |
| | mesquite | 5 | sideoats grama | 46 | 6 | wild indigo | 11 | 3 |
| | live oak | 20 | Virginia wildrye | 31 | 24 | old-mans beard | 11 | 15 |
| | Macartn rose | 10 | switchgrass | 64 | 8 | sunflower | -- | 8 |
| | rattlepod | 2 | longtom | 5 | 7 | coneflower | -- | 2 |
| | greenbriar | 3 | brownseed paspalum | 61 | 20 | snoutbean | 10 | 4 |
| | mustang grape | 20 | thin pasplaum | -- | 36 | bundleflower | 20 | 6 |
| | | | little bluestem | 77 | 29 | mistflower | 10 | 18 |
| | | | knotroot bristle | 20 | 46 | ruellia | 8 | 4 |
| | | | plains bristle | 35 | 30 | bush sunflower | 12 | 18 |
| | | | indiangrass | 64 | 8 | | | |
| | | | Johnsongrass | -- | 50 | | | |
| | | | Texas wintergrass | 10 | 20 | | | |
| | | | littletooth sedge | 5 | 11 | | | |
| | | | Total grasses | 511 | 358 | Total forbs | 100 | 136 |

Appendix Table C.2 (Cont.)

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Clay Loam** | | | | | | | | |
| | huisache | 40 | big bluestem | 22 | 1 | ragweed | 6 | 60 |
| | mesquite | 30 | purple threeawn | 22 | 33 | broomweed | 1 | 10 |
| | live oak | 5 | silver bluestem | 44 | 40 | bundleflower | 5 | 7 |
| | blackbrush | 8 | sideoats grama | 32 | 3 | bush sunflower | 6 | 30 |
| | granjeno | 5 | buffalograss | 29 | 58 | orange zexmenia | 5 | 10 |
| | Macartn rose | 10 | hooded windmill | 22 | 28 | | | |
| | prickly pear | 2 | switchgrass | 10 | 2 | | | |
| | | | brownseed paspalum | 12 | 10 | | | |
| | | | little bluestem | 116 | 50 | | | |
| | | | knotroot bristle | 13 | 15 | | | |
| | | | plains bristle | 53 | 25 | | | |
| | | | indiangrass | 20 | 3 | | | |
| | | | Johnsongrass | -- | 10 | | | |
| | | | Texas wintergrass | 44 | 30 | | | |
| | | | Total grasses | 439 | 308 | Total forbs | 27 | 117 |
| **Claypan Prairie** | | | | | | | | |
| | huisache | 30 | big bluestem | 32 | 2 | ragweed | 10 | 40 |
| | mesquite | 5 | bushy bluestem | -- | 25 | broomweed | 4 | 8 |
| | live oak | 10 | hooded windmill | 5 | 10 | wild indigo | 10 | 48 |
| | baccharis | 10 | bermudagrass | -- | 25 | Texas doveweed | 8 | 15 |
| | Macartn rose | 40 | switchgrass | 30 | 3 | bundleflower | 11 | 8 |
| | rattlepod | 5 | longtom | 35 | 40 | sumpweed | 4 | 6 |
| | | | brownseed paspalum | 45 | 10 | frogfruit | 4 | 6 |
| | | | thin paspalum | -- | 20 | | | |
| | | | little bluestem | 250 | 95 | | | |
| | | | knotroot bristle | 30 | 40 | | | |
| | | | indiangrass | 35 | 4 | | | |
| | | | tall dropseed | 10 | 9 | | | |
| | | | smutgrass | -- | 32 | | | |
| | | | littletooth sedge | 13 | 16 | | | |
| | | | flatsedge | 8 | 14 | | | |
| | | | Total grasses | 493 | 345 | Total forbs | 51 | 131 |
| **Deep Sand** | | | | | | | | |
| | huisache | 5 | big bluestem | 14 | 1 | ragweed | 2 | 44 |
| | mesquite | 5 | arrowfeather | 24 | 38 | partridge pea | 5 | 6 |
| | post oak | 5 | balsamscale | 26 | 48 | Texas doveweed | 4 | 8 |
| | live oak | 60 | switchgrass | 10 | 2 | sunflower | -- | 6 |
| | greenbriar | 2 | brownseed paspalum | 25 | 18 | camphorweed | -- | 10 |
| | mustang grape | 20 | thin paspalum | 2 | 20 | snoutbean | 6 | 3 |
| | prickly pear | 3 | little bluestem | 150 | 75 | bush sunflower | 2 | 10 |
| | | | plains bristle | 22 | 20 | | | |
| | | | indiangrass | 52 | 6 | | | |
| | | | Total grasses | 325 | 228 | Total forbs | 19 | 87 |
| **Gravelly** | | | | | | | | |
| | huisache | 5 | big bluestem | 14 | 2 | ragweed | 4 | 40 |
| | mesquite | 40 | purple threeawn | 20 | 36 | wild indigo | 2 | 9 |
| | post oak | 20 | silver bluestem | 25 | 30 | partridge pea | 3 | 4 |
| | live oak | 15 | sideoats grama | 24 | 9 | bundleflower | 3 | 6 |
| | baccharis | 5 | buffalograss | -- | 20 | sunflower | 1 | 20 |
| | greenbriar | 5 | plains lovegrass | 10 | 15 | snoutbean | 3 | 6 |
| | mustang grape | 5 | switchgrass | 37 | 4 | | | |
| | prickly pear | 5 | brownseed paspalum | 27 | 22 | | | |
| | | | little bluestem | 120 | 68 | | | |
| | | | indiangrass | 42 | 8 | | | |
| | | | Johnsongrass | -- | 10 | | | |
| | | | Total grasses | 319 | 224 | Total forbs | 16 | 85 |

Appendix Table C.2 (Cont.)

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Gray Sandy Loam** | | | | | | | | |
| | huisache | 40 | purple threeawn | 12 | 24 | ragweed | 2 | 16 |
| | mesquite | 35 | silver bluestem | 30 | 15 | broomweed | 2 | 12 |
| | live oak | 3 | sideoats grama | 20 | 8 | Texas doveweed | 2 | 12 |
| | blackbrush | 10 | buffalograss | 25 | 38 | bundleflower | 4 | 3 |
| | granjeno | 10 | sandbur | -- | 8 | sunflower | -- | 16 |
| | prickly pear | 2 | hooded windmill | 20 | 35 | snoutbean | 6 | 4 |
| | | | plains lovegrass | 20 | 10 | bush sunflower | 4 | 6 |
| | | | brownseed paspalum | 24 | 8 | orange zexmenia | 4 | 2 |
| | | | little bluestem | 52 | 24 | | | |
| | | | plains bristle | 30 | 14 | | | |
| | | | indiangrass | 28 | 2 | | | |
| | | | Texas wintergrass | 8 | 2 | | | |
| | | | Total grasses | 269 | 188 | Total forbs | 24 | 71 |
| **Loamy Bottomland** | | | | | | | | |
| | huisache | 10 | big bluestem | 50 | 6 | ragweed | 13 | 40 |
| | pecan | 10 | bushy bluestem | 6 | 30 | giant ragweed | 10 | 49 |
| | hackberry | 15 | silver bluestem | 20 | 18 | spiny aster | 10 | 24 |
| | mesquite | 10 | sideoats grama | 40 | 20 | wild indigo | 6 | 6 |
| | live oak | 20 | buffalograss | 20 | 36 | old-mans beard | 6 | 18 |
| | Macartn rose | 10 | bermudagrass | -- | 20 | bundleflower | 2 | 1 |
| | rattlepod | 2 | Virginia wildrye | 70 | 18 | sunflower | 10 | 20 |
| | greenbriar | 3 | switchgrass | 80 | 16 | sumpweed | -- | 4 |
| | mustang grape | 20 | longtom | 20 | 24 | frogfruit | 2 | 4 |
| | | | brownseed paspalum | 48 | 40 | snoutbean | 8 | 4 |
| | | | little bluestem | 60 | 32 | | | |
| | | | knotroot bristle | 32 | 42 | | | |
| | | | plains bristle | 6 | 12 | | | |
| | | | indiangrass | 80 | 8 | | | |
| | | | Johnsongrass | -- | 24 | | | |
| | | | Texas wintergrass | 16 | 14 | | | |
| | | | littletooth sedge | 55 | 50 | | | |
| | | | flatsedge | 36 | 33 | | | |
| | | | Total grasses | 639 | 447 | Total forbs | 67 | 170 |
| **Loamy Prairie** | | | | | | | | |
| | huisache | 30 | big bluestem | 90 | 4 | ragweed | 6 | 100 |
| | hackberry | 5 | bushy bluestem | 8 | 36 | wild indigo | 12 | 32 |
| | mesquite | 30 | purple threeawn | -- | 16 | partridge pea | 4 | 3 |
| | live oak | 10 | bermudagrass | -- | 12 | bundleflower | 10 | 12 |
| | Macartn rose | 20 | Virginia wildrye | 36 | 6 | sunflower | -- | 32 |
| | prickly pear | 5 | plains lovegrass | 18 | 6 | sumpweed | 1 | 8 |
| | | | switchgrass | 76 | 6 | snoutbean | 6 | 6 |
| | | | longtom | 32 | 36 | bush sunflower | 6 | 32 |
| | | | brownseed paspalum | 72 | 70 | | | |
| | | | thin paspalum | 12 | 32 | | | |
| | | | little bluestem | 400 | 240 | | | |
| | | | knotroot bristle | 24 | 36 | | | |
| | | | indiangrass | 60 | 6 | | | |
| | | | Johnsongrass | -- | 24 | | | |
| | | | smutgrass | -- | 40 | | | |
| | | | Texas wintergrass | 12 | 10 | | | |
| | | | littletooth sedge | 12 | 12 | | | |
| | | | Total grasses | 852 | 592 | Total forbs | 45 | 225 |

Appendix Table C.2 (Cont.)

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Loamy sand** | | | | | | | | |
| | huisache | 5 | big bluestem | 5 | 1 | ragweed | 2 | 14 |
| | hackberry | 5 | bushy bluestem | 6 | 8 | partridge pea | 4 | 3 |
| | mesquite | 30 | arrowfeather | 10 | 16 | Texas doveweed | -- | 8 |
| | live oak | 40 | silver bluestem | 8 | 6 | bundleflower | 2 | 1 |
| | granjeno | 5 | sandbur | -- | 6 | mistflower | 2 | 6 |
| | mustang grape | 10 | hooded windmill | 8 | 8 | sunflower | 2 | 10 |
| | prickly pear | 5 | balsamscale | 12 | 18 | snoutbean | 3 | 3 |
| | | | switchgrass | 12 | 1 | bush sunflower | 6 | 6 |
| | | | brownseed paspalum | 40 | 16 | | | |
| | | | thin paspalum | 10 | 18 | | | |
| | | | little bluestem | 64 | 28 | | | |
| | | | plains bristle | 8 | 2 | | | |
| | | | indiangrass | 4 | 1 | | | |
| | | | smutgrass | -- | 4 | | | |
| | | | Total grasses | 187 | 133 | Total forbs | 21 | 51 |
| **Rolling Blackland** | | | | | | | | |
| | huisache | 40 | big bluestem | 4 | 2 | ragweed | 4 | 36 |
| | hackberry | 3 | purple threeawn | -- | 24 | broomweed | 1 | 24 |
| | mesquite | 35 | silver bluestem | 36 | 30 | wild indigo | 6 | 16 |
| | live oak | 5 | sideoats grama | 50 | 6 | partridge pea | 1 | 1 |
| | baccharis | 3 | buffalograss | 56 | 60 | bundleflower | 3 | 4 |
| | Macartn rose | 10 | hooded windmill | 4 | 12 | sunflower | 1 | 12 |
| | greenbriar | 2 | bermudagrass | -- | 8 | frogfruit | 2 | 8 |
| | prickly pear | 2 | Virginia wildrye | 12 | 4 | snoutbean | 4 | 4 |
| | | | plains lovegrass | 34 | 24 | | | |
| | | | switchgrass | 12 | 2 | | | |
| | | | longtom | 6 | 4 | | | |
| | | | brownseed paspalum | 12 | 4 | | | |
| | | | thin paspalum | 6 | 8 | | | |
| | | | little bluestem | 70 | 4 | | | |
| | | | knotroot bristle | 12 | 15 | | | |
| | | | plains bristle | 32 | 20 | | | |
| | | | indiangrass | 4 | 2 | | | |
| | | | tall dropseed | 12 | 4 | | | |
| | | | smutgrass | -- | 12 | | | |
| | | | Texas wintergrass | 30 | 30 | | | |
| | | | Total grasses | 392 | 275 | Total forbs | 22 | 105 |
| **Salt Marsh** | | | | | | | | |
| | baccharis | 50 | bermudagrass | -- | 10 | spiny aster | -- | 12 |
| | sea oxeye | 50 | saltgrass | 120 | 80 | glasswort | 12 | 18 |
| | | | switchgrass | 12 | 2 | frogfruit | 2 | 6 |
| | | | longtom | 16 | 8 | sumpweed | 12 | 24 |
| | | | common reed | 50 | 60 | | | |
| | | | little bluestem | 12 | 4 | | | |
| | | | knotroot bristle | 15 | 12 | | | |
| | | | plains bristle | 8 | 2 | | | |
| | | | indiangrass | 6 | 2 | | | |
| | | | gulf cordgrass | 720 | 480 | | | |
| | | | Olney bulrush | 50 | 46 | | | |
| | | | Total grasses | 1009 | 706 | Total forbs | 26 | 60 |
| **Salty Bottomland** | | | | | | | | |
| | huisache | 50 | buffalograss | 10 | 6 | spiny aster | 2 | 24 |
| | mesquite | 10 | bermudagrass | -- | 20 | sumpweed | 24 | 36 |
| | sea oxeye | 35 | saltgrass | 76 | 54 | glasswort | 24 | 30 |
| | rattlepod | 5 | little bluestem | 25 | 2 | | | |
| | | | gulf cordgrass | 354 | 244 | | | |
| | | | Olney bulrush | 35 | 24 | | | |
| | | | Total grasses | 500 | 350 | Total forbs | 50 | 90 |

Appendix Table C.2 (Cont.)

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Sandy Bottomland** | | | | | | | | |
| | huisache | 5 | big bluestem | 32 | 2 | ragweed | 6 | 16 |
| | pecan | 5 | purple threeawn | 12 | 24 | giant ragweed | -- | 24 |
| | hackberry | 15 | silver bluestem | 8 | 8 | partridge pea | 4 | 2 |
| | mesquite | 5 | sandbur | -- | 8 | mistflower | 8 | 20 |
| | live oak | 50 | bermudagrass | -- | 30 | sunflower | 2 | 8 |
| | mustang grape | 20 | Virginia wildrye | 32 | 16 | snoutbean | 6 | 4 |
| | | | switchgrass | 48 | 4 | | | |
| | | | thin paspalum | -- | 12 | | | |
| | | | little bluestem | 80 | 32 | | | |
| | | | knotroot bristle | 32 | 32 | | | |
| | | | indiangrass | 30 | 2 | | | |
| | | | Johnsongrass | -- | 20 | | | |
| | | | tall dropseed | 6 | 4 | | | |
| | | | Total grasses | 280 | 194 | Total forbs | 26 | 74 |
| **Sandy Loam** | | | | | | | | |
| | huisache | 5 | big bluestem | 30 | 2 | ragweed | 10 | 56 |
| | hackberry | 5 | arrowfeather | 24 | 36 | broomweed | 2 | 40 |
| | mesquite | 35 | silver bluestem | 40 | 36 | partridge pea | 8 | 6 |
| | post oak | 5 | sideoats grama | 32 | 4 | Texas doveweed | 2 | 12 |
| | live oak | 30 | buffalograss | 12 | 24 | bundleflower | 4 | 2 |
| | blackbrush | 5 | sandbur | -- | 6 | sumpweed | 1 | 4 |
| | granjeno | 10 | bermudagrass | -- | 32 | snoutbean | 4 | 6 |
| | prickly pear | 5 | Virginia wildrye | 16 | 4 | bush sunflower | 8 | 20 |
| | | | balsamscale | 24 | 40 | | | |
| | | | plains lovegrass | 16 | 8 | | | |
| | | | brownseed paspalum | 36 | 30 | | | |
| | | | thin paspalum | 4 | 18 | | | |
| | | | little bluestem | 233 | 100 | | | |
| | | | knotroot bristle | 8 | 10 | | | |
| | | | plains bristle | 30 | 12 | | | |
| | | | indiangrass | 24 | 2 | | | |
| | | | tall dropseed | 12 | 8 | | | |
| | | | Texas wintergrass | 8 | 12 | | | |
| | | | Total grasses | 549 | 384 | Total forbs | 39 | 146 |
| **Sandy Prairie** | | | | | | | | |
| | huisache | 25 | big bluestem | 84 | 6 | ragweed | 8 | 80 |
| | mesquite | 35 | arrowfeather | 30 | 64 | partridge pea | 4 | 6 |
| | live oak | 35 | silver bluestem | 12 | 20 | Texas doveweed | 4 | 24 |
| | prickly pear | 5 | sideoats grama | 8 | 6 | bundleflower | 6 | 6 |
| | | | sandbur | 4 | 12 | mistflower | 8 | 36 |
| | | | Virginia wildrye | 30 | 12 | sunflower | 4 | 16 |
| | | | balsamscale | 36 | 60 | camphorweed | 6 | 48 |
| | | | switchgrass | 30 | 4 | sumpweed | 2 | 4 |
| | | | brownseed paspalum | 48 | 36 | snoutbean | 4 | 6 |
| | | | little bluestem | 480 | 328 | | | |
| | | | knotroot bristle | 18 | 36 | | | |
| | | | plains bristle | 24 | 8 | | | |
| | | | indiangrass | 48 | 4 | | | |
| | | | Total grasses | 852 | 596 | Total forbs | 46 | 226 |
| **Shallow** | | | | | | | | |
| | huisache | 5 | purple threeawn | 12 | 24 | ragweed | 6 | 18 |
| | mesquite | 35 | silver bluestem | 36 | 30 | broomweed | 2 | 12 |
| | live oak | 5 | sideoats grama | 40 | 8 | Texas doveweed | 4 | 8 |
| | blackbrush | 50 | buffalograss | 20 | 30 | bundleflower | 2 | 2 |
| | prickly pear | 5 | hooded windmill | 8 | 12 | bush sunflower | 2 | 6 |
| | | | plains lovegrass | 16 | 4 | orange zexmenia | 6 | 8 |
| | | | little bluestem | 46 | 13 | | | |
| | | | plains bristle | 16 | 4 | | | |
| | | | Texas wintergrass | 8 | 16 | | | |
| | | | Total grasses | 202 | 141 | Total forbs | 22 | 54 |

Appendix Table C.2 (Cont.)

| Range Type | Woody Species | Relative Cover (%) | Grasses | Biomass Late | Biomass Mid | Forbs | Biomass Late | Biomass Mid |
|---|---|---|---|---|---|---|---|---|
| **Tight Sandy Loam** | | | | | | | | |
| | huisache | 15 | purple threeawn | 36 | 60 | ragweed | 10 | 45 |
| | hackberry | 10 | silver bluestem | 100 | 108 | broomweed | 2 | 30 |
| | mesquite | 30 | sideoats grama | 60 | 24 | Texas doveweed | 3 | 24 |
| | post oak | 10 | sandbur | -- | 12 | bundleflower | 4 | 3 |
| | live oak | 10 | hooded windmill | 62 | 62 | sunflower | 4 | 24 |
| | blackbrush | 10 | balsamscale | 60 | 54 | snoutbean | 6 | 4 |
| | granjeno | 10 | switchgrass | 30 | 4 | bush sunflower | 10 | 27 |
| | prickly pear | 5 | brownseed paspalum | 14 | 8 | | | |
| | | | thin paspalum | 4 | 16 | | | |
| | | | little bluestem | 80 | 20 | | | |
| | | | plains bristle | 52 | 18 | | | |
| | | | indiangrass | 30 | 6 | | | |
| | | | Texas wintergrass | 60 | 20 | | | |
| | | | Total grasses | 588 | 412 | Total forbs | 39 | 157 |

Appendix Table C.3 Species composition (% cover for woody species, g/m$^2$ annual aboveground production for herbaceous species, average rainfall) on **clay and clay loam** NRCS range sites under late-seral (excellent range condition) conditions in Victoria County (x = species occurs in early- or mid-seral).

| Species | Blackland | Clayey Bottomland | Clay Loam | Loamy Bottomland | Rolling Blackland | Salty Bottomland | Salt Marsh |
|---|---|---|---|---|---|---|---|
| Huisache | x | x | x | x | x | x | --- |
| Pecan | --- | 5 | --- | 5 | --- | --- | --- |
| Hackberry | x | 5 | --- | 5 | 1 | --- | --- |
| Mesquite | x | x | 5 | x | x | 5 | --- |
| Live oak | x | 5 | x | 10 | 2 | --- | --- |
| Blackbrush | --- | --- | x | --- | --- | --- | --- |
| Baccharis | x | --- | --- | --- | x | --- | x |
| Sea oxeye | --- | --- | --- | --- | --- | 10 | 10 |
| Granjeno | --- | --- | 5 | --- | 1 | --- | --- |
| Macartney rose | x | x | x | x | x | --- | --- |
| Rattlepod | --- | --- | --- | x | --- | x | --- |
| Greenbriar | x | x | --- | x | x | --- | --- |
| Mustang grape | --- | 5 | --- | x | --- | --- | --- |
| Prickly pear | x | --- | x | x | x | 5 | --- |
| Big bluestem | 40 | 65 | 22 | 50 | 4 | --- | --- |
| Bushy bluestem | x | 2 | --- | 6 | --- | --- | --- |
| Purple threeawn | x | --- | 22 | --- | x | --- | --- |
| Silver bluestem | --- | 26 | 44 | 20 | 36 | --- | --- |
| Sideoats grama | 81 | 46 | 32 | 40 | 50 | --- | --- |
| Buffalograss | 20 | --- | 29 | 20 | 56 | 10 | --- |
| Hooded windmillgrass | --- | --- | 22 | --- | 4 | --- | --- |
| Bermudagrass | x | --- | --- | x | x | x | x |
| Saltgrass | --- | --- | --- | --- | --- | 76 | 120 |
| Virginia wildrye | 24 | 31 | --- | 70 | 12 | --- | --- |
| Plains lovegrass | --- | --- | --- | --- | 34 | --- | --- |
| Switchgrass | 40 | 64 | 10 | 80 | 12 | --- | 12 |
| Longtom | 24 | 5 | --- | 20 | 6 | --- | 16 |
| Brownseed paspalum | 48 | 61 | 12 | 48 | 12 | --- | --- |
| Thin paspalum | x | x | --- | --- | 6 | --- | --- |
| Common reed | --- | --- | --- | --- | --- | --- | 50 |
| Little bluestem | 363 | 77 | 116 | 60 | 70 | 25 | 12 |
| Knotroot bristlegrass | 24 | 20 | 13 | 32 | 12 | --- | 15 |
| Plains bristlegrass | x | 35 | 53 | 6 | 32 | --- | 8 |
| Indiangrass | 81 | 64 | 20 | 80 | 4 | --- | 6 |
| Johnsongrass | x | x | x | x | --- | --- | --- |
| Gulf cordgrass | --- | --- | --- | --- | --- | 354 | 720 |
| Tall dropseed | 24 | --- | --- | --- | 12 | --- | --- |
| Smutgrass | x | --- | --- | --- | x | --- | --- |
| Texas wintergrass | 24 | 10 | 44 | 16 | 30 | --- | --- |
| Littletooth sedge | --- | 5 | --- | 55 | --- | --- | --- |
| Flatsedge | x | --- | --- | 36 | --- | --- | --- |
| Olney bulrush | --- | --- | --- | --- | --- | 35 | 50 |
| Ragweed | x | 6 | 6 | 13 | 4 | --- | --- |
| Giant ragweed | --- | x | --- | 10 | --- | --- | --- |
| Annual broomweed | --- | --- | 1 | --- | 1 | --- | --- |
| Spiny aster | --- | 12 | --- | 10 | x | 2 | x |
| Wild indigo | 9 | 11 | --- | 6 | 6 | --- | --- |
| Old-mans beard | x | 11 | --- | 6 | --- | --- | --- |
| Texas doveweed | --- | --- | --- | --- | --- | --- | --- |
| Bundleflower | 9 | 20 | 5 | 2 | 3 | --- | --- |
| Mistflower | --- | 10 | --- | --- | --- | --- | --- |
| Sunflower | x | x | --- | 10 | 1 | --- | --- |
| Camphorweed | --- | --- | --- | --- | --- | --- | --- |
| Sumpweed | --- | --- | --- | x | --- | 24 | 12 |
| Frogfruit | x | --- | --- | 2 | 2 | --- | 2 |
| Prairie coneflower | 8 | x | --- | --- | --- | --- | --- |
| Snoutbean | --- | 10 | --- | 8 | 4 | --- | --- |
| Ruellia | --- | 8 | --- | --- | --- | --- | --- |
| Glasswort | --- | --- | --- | --- | --- | 24 | 12 |
| Bush sunflower | 9 | 12 | 6 | --- | --- | --- | --- |
| Orange zexmenia | --- | --- | 5 | --- | --- | --- | --- |
| Total herbaceous | 828 | 611 | 466 | 706 | 414 | 550 | 1035 |

Appendix Table C.4 Species composition (% cover for woody species, $g/m^2$ annual aboveground production for herbaceous species, average rainfall) on **sandy, sandy loam, and loam** NRCS range sites under late-seral (excellent range condition) conditions in Victoria County (x = species occurs in early- or mid-seral).

| Species | Gray Sandy Loam | Claypan Prairie | Loamy Prairie | Sandy Loam | Tight Sandy Loam | Sandy Prairie | Loamy Sand | Deep Sand | Sandy Bottomland |
|---|---|---|---|---|---|---|---|---|---|
| Huisache | x | x | x | x | x | x | x | x | x |
| Pecan | --- | --- | --- | --- | --- | --- | --- | --- | 3 |
| Sugar hackberry | --- | --- | x | x | x | --- | x | --- | 2 |
| Mesquite | 10 | x | x | x | 5 | x | 5 | x | x |
| Post oak | --- | --- | --- | 5 | x | --- | --- | 3 | --- |
| Live oak | x | x | x | 15 | x | x | 10 | 12 | 10 |
| Blackbrush | 5 | --- | --- | x | x | --- | --- | --- | --- |
| Baccharis | --- | x | --- | --- | --- | --- | --- | --- | --- |
| Granjeno | 5 | --- | --- | 5 | 5 | --- | x | --- | --- |
| McCartney rose | --- | x | x | --- | --- | --- | --- | --- | --- |
| Rattlepod | --- | x | --- | --- | --- | --- | --- | --- | --- |
| Greenbriar | --- | --- | --- | --- | --- | --- | --- | x | --- |
| Mustang grape | --- | --- | --- | --- | --- | --- | 3 | x | 5 |
| Prickly pear | x | --- | x | x | x | x | 2 | x | --- |
| | | | | | | | | | |
| Big bluestem | --- | 32 | 90 | 30 | --- | 84 | 5 | 14 | 32 |
| Bushy bluestem | --- | --- | 8 | --- | --- | --- | 6 | --- | --- |
| Arrowfeather threeawn | -- | --- | --- | 24 | --- | 30 | 10 | 24 | --- |
| Purple threeawn | 12 | --- | --- | --- | 36 | --- | --- | --- | 12 |
| Silver bluestem | 30 | --- | --- | 40 | 100 | 12 | 8 | --- | 8 |
| Sideoats grama | 20 | --- | --- | 32 | 60 | 8 | --- | --- | --- |
| Buffalograss | 25 | --- | --- | 12 | --- | --- | --- | --- | --- |
| Sandbur | x | --- | --- | x | x | 4 | x | --- | x |
| Hooded windmill | 20 | 5 | --- | --- | 62 | --- | 8 | --- | --- |
| Bermudagrass | --- | x | x | x | --- | --- | --- | --- | x |
| Virginia wildrye | --- | --- | 36 | 16 | --- | 30 | --- | --- | 32 |
| Balsamscale | --- | --- | --- | 24 | 60 | 36 | 12 | 26 | --- |
| Plains lovegrass | 20 | --- | 18 | 16 | --- | --- | --- | --- | --- |
| Switchgrass | --- | 30 | 76 | --- | 30 | 30 | 12 | 10 | 48 |
| Longtom | --- | 35 | 32 | --- | --- | --- | --- | --- | --- |
| Brownseed paspalum | 24 | 45 | 72 | 36 | 14 | 48 | 40 | 25 | --- |
| Thin paspalum | --- | x | 12 | 4 | 4 | --- | 10 | 2 | x |
| Little bluestem | 52 | 250 | 400 | 233 | 80 | 480 | 64 | 150 | 80 |
| Knotroot bristle | --- | 30 | 24 | 8 | --- | 18 | --- | --- | 32 |
| Plains bristlegrass | 30 | --- | --- | 30 | 52 | 24 | 8 | 22 | --- |
| Indiangrass | 28 | 35 | 60 | 24 | 30 | 48 | 4 | 52 | 30 |
| Johnsongrass | --- | --- | x | --- | --- | --- | --- | --- | x |
| Tall dropseed | --- | 10 | --- | 12 | --- | --- | --- | --- | 6 |
| Smutgrass | --- | x | x | --- | --- | --- | x | --- | --- |
| Texas wintergrass | 8 | --- | 12 | 8 | 60 | --- | --- | --- | --- |
| Littletooth sedge | --- | 13 | 12 | --- | --- | --- | --- | --- | --- |
| Flatsedge | --- | 8 | --- | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | |
| Ragweed | 2 | 10 | 6 | 10 | 10 | 8 | 2 | 2 | 6 |
| Giant ragweed | --- | --- | --- | --- | --- | --- | --- | --- | x |
| Annual broomweed | 2 | 4 | --- | 2 | 2 | --- | --- | --- | --- |
| Wild indigo | --- | 10 | 12 | --- | --- | --- | --- | --- | --- |
| Partridge pea | --- | --- | 4 | 8 | --- | 4 | 4 | 5 | 4 |
| Texas doveweed | 2 | 8 | --- | 2 | 3 | 4 | x | 4 | --- |
| Bundleflower | 4 | 11 | 10 | 4 | 4 | 6 | 2 | --- | --- |
| Mistflower | --- | --- | --- | --- | --- | 8 | 2 | --- | 8 |
| Sunflower | x | --- | x | --- | 4 | 4 | 2 | x | 2 |
| Camphorweed | --- | --- | --- | --- | --- | 6 | --- | x | --- |
| Sumpweed | --- | 4 | 1 | 1 | --- | 2 | --- | --- | --- |
| Frogfruit | --- | 4 | --- | --- | --- | --- | --- | --- | --- |
| Snoutbean | 6 | --- | 6 | 4 | 6 | 4 | 3 | 6 | 6 |
| Bush sunflower | 4 | --- | 6 | 8 | 10 | --- | 6 | 2 | --- |
| | | | | | | | | | |
| Total herbaceous | 293 | 544 | 897 | 588 | 627 | 898 | 208 | 344 | 306 |

Appendix Table C.5 Species composition (% cover for woody species, g/m$^2$ annual aboveground production for herbaceous species, average rainfall) on **shallow** NRCS range sites under late-seral (excellent range condition) conditions in Victoria County (x = species occurs in early- or mid-seral).

| Species | Gravelly | Shallow |
|---|---|---|
| Huisache | x | x |
| Mesquite | x | 4 |
| Post oak | 8 | --- |
| Live oak | 2 | 2 |
| | | |
| Baccharis | x | --- |
| Blackbrush | 15 | 3 |
| Granjeno | --- | --- |
| Greenbriar | 2 | --- |
| Mustang grape | 3 | --- |
| Prickly pear | x | 1 |
| | | |
| Big bluestem | 14 | --- |
| Purple threeawn | 20 | 12 |
| Silver bluestem | 25 | 36 |
| Sideoats grama | 24 | 40 |
| Buffalograss | x | 20 |
| Hooded windmill | --- | 8 |
| Plains lovegrass | 10 | 16 |
| Switchgrass | 37 | --- |
| Brownseed paspalum | 27 | --- |
| Little bluestem | 120 | 46 |
| Plains bristlegrass | --- | 16 |
| Indiangrass | 42 | --- |
| Johnsongrass | x | --- |
| Texas wintergrass | --- | 8 |
| | | |
| Ragweed | 4 | 6 |
| Annual broomweed | --- | 2 |
| Wild indigo | 2 | --- |
| Partridge pea | 3 | --- |
| Texas doveweed | --- | 4 |
| Bundleflower | 3 | 2 |
| Sunflower | 1 | --- |
| Snoutbean | 3 | --- |
| Bush sunflower | --- | 2 |
| Orange zexmenia | --- | 6 |
| | | |
| Total herbaceous | 335 | 224 |

Appendix Table C.6 Species composition (% cover for woody species, g/m$^2$ annual aboveground production for herbaceous species) on **freshwater wetlands** under late-seral (excellent range condition) conditions in Victoria County (x = species occurs in early- or mid-seral).

| Species | Freshwater Wetland |
|---|---|
| Huisache | x |
| Hackberry | 10 |
| Mesquite | x |
| | |
| Baccharis | x |
| Macartney rose | x |
| Rattlepod | x |
| | |
| Bushy bluestem | 34 |
| Buffalograss | 8 |
| Bermudagrass | x |
| Virginia wildrye | 20 |
| Switchgrass | 101 |
| Longtom | 90 |
| Brownseed paspalum | 45 |
| Common reed | x |
| Little bluestem | 40 |
| Knotroot bristlegrass | 34 |
| Johnsongrass | x |
| Smutgrass | x |
| | |
| Littletooth sedge | 11 |
| Flatsedge | 22 |
| Cattail | 150 |
| | |
| Ragweed | 4 |
| Spiny aster | x |
| Wild indigo | 8 |
| Old-mans beard | 24 |
| Bundleflower | 2 |
| Mistflower | 12 |
| Sunflower | 2 |
| Camphorweed | x |
| Sumpweed | 2 |
| Frogfruit | 2 |
| | |
| Total herbaceous | 611 |

Appendix Table C.7 Comparison of vegetation data from literature sources for clay and clay loam sites in South Texas.

| Species | Box & White (1969) Relative | Box & White (1969) Absolute | Box (1961) Victoria | Box (1961) Orelia | Powell & Box 1967 Victoria | Buckley & Dodd 1969 clay | Dodd & Holtz (1972) | Johnston (1963) |
|---|---|---|---|---|---|---|---|---|
| | | | **Welder Wildlife Refuge** | | | **Webb** | **Goliad** | **Kleberg** |
| *Acacia farnesiana* | 10.0 | 4.7 | 5.5 | 1.3 | x | | | |
| *Acacia rigidula* | 9.0 | 4.2 | 18.4 | 0.5 | x | | | |
| *Acacia tortuosa* | t | t | 2.9 | 1.3 | | | | |
| *Berberis trifoliolata* | 4.1 | 1.9 | 6.4 | t | x | | | |
| *Celtis pallida* | 5.0 | 2.4 | 1.2 | --- | x | | | |
| *Condalia obovata* | 2.0 | 0.9 | 0.9 | --- | x | | | |
| *Diospyros texana* | 1.0 | 0.5 | --- | --- | | | | |
| *Lycium berlandieri* | 1.0 | 0.5 | --- | --- | | | | |
| *Opuntia leptocaulis* | 4.7 | 2.2 | --- | --- | | | | |
| *Opuntia linheimeri* | 8.4 | 3.7 | t | 52.3 | | x | | |
| *Parkinsonia aculeata* | | | | | | x | | |
| *Prosopis glandulosa* | 43.2 | 20.3 | 53.0 | 38.2 | x | x | | |
| *Prosopis reptans* | 4.6 | 2.2 | --- | --- | | | | |
| *Varilla texana* | | | | | | x | | |
| *Zanthoxylum fagara* | 3.8 | 1.8 | 3.9 | 1.3 | x | | | |
| *Zizyphus obtusifolia* | 2.5 | 1.2 | 7.8 | 5.1 | | | | |
| Total woody (abs cover) | | 46.5 | 19.6 | 39.4 | 48.6 | | | |
| *Aristida roemeriana* | 3.3 | 5.4 | 14.3 | 7.6 | 2.3 | | | 2% |
| *Aristida* spp. | | | | | | | 6.4 | |
| *Bothriochloa saccharoides* | 8.7 | 14.1 | 0.6 | 0.5 | 4.5 | | | |
| *Bouteloua curtipendula* | | | | | | | 1.7 | |
| *Bouteloua rigidiseta* | | | | | 0.3 | | 8.3 | |
| *Bouteloua trifida* | | | | | | 2.3 | | |
| *Buchloe dactyloides* | 24.4 | 39.8 | 27.6 | 11.3 | 28.6 | | | 30% |
| *Cenchrus ciliaris* | | | | | | 4.0 | | |
| *Cenchrus incertus* | --- | --- | 0.1 | 7.3 | | 1.9 | | 2% |
| *Chloris cucullata* | | | | | | | 1.2 | |
| *Chloris verticillata* | 1.4 | 2.2 | 2.5 | 25.0 | 1.6 | | | 15% |
| *Cynodon dactylon* | | | | | 0.6 | | | |
| *Digitaria californica* | --- | --- | 0.3 | 0.1 | | | | |
| *Eragrostis lugens* | | | | | 3.9 | | | |
| *Eriochloa contracta* | --- | --- | 0.4 | t | 3.9 | 0.3 | | |
| *Hilaria belangeri* | t | t | 16.9 | 20.9 | 1.0 | 27.8 | | 20% |
| *Leptochloa dubia* | | | | | | 6.6 | | |
| *Leptochloa nealleyi* | | | | | 2.2 | | | |
| *Leptoloma cognatum* | --- | --- | 0.1 | 0.1 | | | 0.6 | |
| *Panicum filipes* | 3.0 | 4.8 | 10.6 | 2.3 | 6.9 | | | 5% |
| *Panicum hallii* | | | | | | 78.2 | | |
| *Panicum obtusum* | 1.4 | 2.2 | 2.0 | t | 2.2 | | | |
| *Paspalum pubiflorum* | 3.9 | 6.4 | 0.4 | 0.6 | 6.0 | | | |
| *Schedonnardus paniculatus* | 0.3 | 0.4 | --- | --- | | | | 2% |
| *Schizachyrium scoparium* | | | | | | | 1.2 | |
| *Setaria geniculata* | 0.9 | 1.5 | 0.4 | 0.5 | 5.3 | | | |
| *Setaria leucopila* | 0.8 | 1.3 | 17.8 | 15.0 | 20.2 | | 1.2 | |
| *Sporobolus asper* | 2.5 | 4.0 | --- | --- | 1.4 | | | |
| *Sporobolus cryptandrus* | | | | | | | 0.6 | |
| *Sporobolus pyramidatus* | 0.4 | 0.7 | 0.2 | 4.5 | 1.7 | 14.4 | | |
| *Stipa leucotricha* | 5.3 | 8.6 | 0.9 | 0.9 | 5.8 | | 1.7 | |
| *Tridens albescens* | 2.1 | 3.5 | 0.7 | t | 1.4 | | | |
| *Tridens congestus* | 1.5 | 2.5 | --- | --- | | | | |
| *Tridens eragrostoides* | --- | --- | t | 0.5 | | | | |
| *Tridens texensis* | | | | | | | 2.3 | |
| Other grasses (4) | 0.2 | 0.3 | 0.2 | 0.2 | | | 6.4 | |
| *Carex* spp. | | | | | | | 9.9 | |
| Total grasses ($g/m^2$) | 60.1 | 97.7 | | | 99.8 | 135.5 | 41.5 | |
| Total grasses (% cover) | | | 96.0 | 97.3 | | | | |
| *Ambrosia psilostachya* | 4.9 | 8.6 | --- | --- | 20.4 | | | |
| *Cienfuegosa sulphurea* | 0.3 | 0.4 | --- | --- | | | | |

Appendix Table C.7 (Cont.)

| Species | Box & White (1969) Relative | Box & White (1969) Absolute | Box (1961) Victoria | Box (1961) Orelia | Powell & Box 1967 Victoria | Buckley & Dodd 1969 clay | Dodd & Holtz (1972) | Johnston (1963) |
|---|---|---|---|---|---|---|---|---|
| *Commelina erecta* | 1.6 | 2.7 | 0.1 | t | | | | |
| *Croton monanthogynus* | 2.8 | 4.5 | 0.9 | t | | | | |
| *Desmanthus virgatus* | 2.1 | 3.5 | --- | --- | | | | 5% |
| *Euphorbia albomarginata* | | | | | | | | 2% |
| *Evolvulus sericeus* | | | | | | | | 2% |
| *Lythrum californicum* | 0.1 | 0.2 | --- | --- | | | | |
| *Malvastrum aurantiacum* | 0.2 | 0.3 | --- | --- | | | | |
| *Phyla incisa* | 0.5 | 0.9 | t | t | | | | |
| *Portulaca pilosa* | 0.5 | 0.9 | --- | --- | | | | |
| *Ratibida columnaris* | 0.1 | 0.2 | 0.6 | t | | | | |
| *Ruellia* sp. | 7.6 | 12.3 | 0.8 | t | | | | |
| *Solanum eleagnifolium* | 1.6 | 2.6 | --- | --- | | | | |
| *Verbesina microptera* | 2.1 | 3.5 | --- | --- | | | | |
| *Xanthocephalum texanum* | 15.0 | 24.5 | 0.1 | 0.5 | 20.4 | | | |
| Other forbs (11) | 0.5 | 0.8 | 1.0 | t | | | | |
| Total forbs | 39.9 | 65.9 | 3.5 | 0.5 | 40.8 | | 104.2 | |
| Total herbaceous ($g/m^2$) | 100.0 | 163.6 | | | 140.6 | | 145.7 | |
| Total herbaceous (% cover) | | | 99.5 | 97.8 | | | | |

Box and White (1969) was a chaparral community on Victoria clay. Box (1961) is % relative basal cover. Victoria communities are an average of mesquite and chaparral communities and Orelia community is a prickly pear site.

Appendix Table C.8 Basal cover (%) and composition (% relative basal cover) on late-successional Fayette Prairie clay and clay loam sites (Smeins and Diamond 1983).

| Species | Basal Cover | | Composition | |
|---|---|---|---|---|
| | Upland | Lowland | Upland | Lowland |
| *Andropogon gerardii* | 3 | t | 2.0 | t |
| *Bouteloua curtipendula* | 6 | 0 | 3.7 | 0.0 |
| *Coelorachis cylindrica* | 3 | 0 | 2.0 | 0.0 |
| *Dichanthelium sphaerocarpon* | 2 | 0 | 1.0 | 0.0 |
| *Eragrostis intermedia* | 1 | 0 | 0.3 | 0.0 |
| *Eriochloa sericea* | 2 | 0 | 1.0 | 0.0 |
| *Muhlenbergia capillaris* | 3 | 0 | 1.7 | 0.0 |
| *Panicum virgatum* | 0 | 18 | 0.0 | 22.0 |
| *Paspalum floridanum* | 4 | 5 | 2.7 | 6.1 |
| *Paspalum plicatulum* | 7 | 0 | 4.3 | 0.0 |
| *Paspalum setaceum* | 3 | 0 | 1.7 | 0.0 |
| *Schizachyrium scoparium* | 59 | t | 39.0 | t |
| *Sorghastrum nutans* | 11 | 10 | 7.3 | 12.2 |
| *Sporobolus asper* | 4 | 2 | 2.7 | 2.4 |
| *Stipa leucotricha* | 3 | 0 | 2.0 | 0.0 |
| *Tripsacum dactyloides* | 12 | 41 | 7.7 | 50.0 |
| | | | | |
| *Carex microdonta* | 4 | t | 2.7 | t |
| *Eleocharis montevidensis* | 2 | 3 | 1.0 | 3.7 |
| *Fimbristylis puberula* | 2 | 0 | 1.3 | 0.0 |
| *Scleria ciliata* | 2 | 0 | 1.3 | 0.0 |
| | | | | |
| *Argythamnia humilis* | 2 | 0 | 1.0 | 0.0 |
| *Biforia americana* | 1 | 0 | 0.7 | 0.0 |
| *Cacalia plantaginea* | 3 | 0 | 1.7 | 0.0 |
| *Desmanthus illinoensis* | 0 | 2 | 0.0 | 2.4 |
| *Dyschoriste linearis* | 2 | 0 | 1.3 | 0.0 |
| *Echinacea angustifolia* | 1 | 0 | 0.7 | 0.0 |
| *Krigia occidentalis* | 2 | 0 | 1.3 | 0.0 |
| *Marshallia caespitosa* | 4 | 0 | 2.7 | 0.0 |
| *Physotegia intermedia* | 3 | 1 | 1.7 | 1.2 |
| *Rudbeckia hirta* | 2 | 0 | 1.3 | 0.0 |
| *Ruellia nudiflora* | 2 | 0 | 1.3 | 0.0 |
| | | | | |
| Grasses | | | 79.1 | 92.7 |
| Grass-likes | | | 6.3 | 3.7 |
| Forbs | | | 13.7 | 3.6 |

Appendix Table C.9 Comparison of vegetation data from literature sources for sandy and sandy loam sites in South Texas. Values are percent composition unless otherwise noted.

| Species | Box (1961) Nueces fs | Drawe & Box (1969) Zavala fsl | | Diamond & Smeins (1984) Alfisols | Bovey et al. (1972) Katy sl | McLendon & DeYoung (1976) | McLendon | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ($g/m^2$) | (%) | | | | (2014) Aransas ($g/m^2$) | (2015) Goliad ($g/m^2$) | (2015) Karnes ($g/m^2$) |
| *Ampelopsis arborea* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 22.7 | ---- |
| *Baccharis glutinosa* | ---- | ---- | ---- | --- | ---- | 2.7 | ---- | ---- | ---- |
| *Quercus virginiana* | ---- | ---- | ---- | --- | 114.2 | 8.6 | ---- | ---- | ---- |
| *Vitis mustangensis* | ---- | ---- | ---- | --- | ---- | | 27.0 | ---- | ---- |
| | | | | | | | | | |
| *Andropogon glomeratus* | ---- | ---- | ---- | --- | ---- | 4.3 | ---- | ---- | ---- |
| *Aristida purpurescens* | 1.2 | ---- | ---- | 6 | x | ---- | ---- | ---- | ---- |
| *Bothriochloa ischaemum* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 34.7 | ---- |
| *Bothriochloa saccharoides* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 96.0 |
| *Bouteloua curtipendula* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 1.1 |
| *Bouteloua hirsuta* | 1.8 | ---- | ---- | --- | ---- | ---- | ---- | ---- | ---- |
| *Brachiaria ciliatissima* | 3.2 | 22.0 | 9.3 | --- | ---- | ---- | ---- | ---- | ---- |
| *Cenchrus incertus* | 13.7 | 23.1 | 9.7 | --- | ---- | 2.0 | 1.1 | ---- | ---- |
| *Chloris cucullata* | 4.2 | ---- | ---- | --- | ---- | ---- | ---- | ---- | 17.1 |
| *Cynodon dactylon* | ---- | ---- | ---- | --- | ---- | 3.0 | ---- | ---- | 17.2 |
| *Dichanthelium acuminatum* | ---- | ---- | ---- | --- | ---- | ---- | 6.1 | ---- | 8.0 |
| *Dichanthelium langinosum* | ---- | ---- | ---- | --- | ---- | 3.0 | ---- | ---- | ---- |
| *Dichanthelium oligosanthes* | ---- | ---- | ---- | 4 | ---- | 4.0 | ---- | ---- | ---- |
| *Dichanthelium sphaerocarpon* | --- | ---- | ---- | --- | ---- | 3.7 | ---- | ---- | ---- |
| *Digitaria texana* | ---- | ---- | ---- | --- | ---- | 2.7 | ---- | ---- | ---- |
| *Elyonurus tripsacoides* | 3.1 | 30.0 | 12.3 | --- | ---- | ---- | 57.4 | ---- | ---- |
| *Eragrostis secundiflora* | 1.2 | ---- | ---- | x | ---- | ---- | ---- | ---- | ---- |
| *Eragrostis trichodes* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 29.0 |
| *Eustachys petraea* | ---- | ---- | ---- | --- | ---- | 1.6 | ---- | ---- | ---- |
| *Leptoloma cognatum* | 2.1 | ---- | ---- | --- | ---- | ---- | ---- | ---- | ---- |
| *Panicum capillare* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 0.8 | ---- |
| *Panicum hallii* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 0.4 |
| *Panicum maximum* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 67.1 | ---- |
| *Paspalum floridanum* | ---- | ---- | ---- | 3 | ---- | ---- | 5.0 | ---- | ---- |
| *Paspalum monostachyum* | ---- | ---- | ---- | --- | ---- | 11.5 | ---- | ---- | ---- |
| *Paspalum plicatulum* | 0.4 | ---- | ---- | 10 | x | 5.8 | ---- | ---- | ---- |
| *Paspalum setaceum* | 4.4 | ---- | ---- | 3 | ---- | 3.6 | 3.6 | ---- | 18.2 |
| *Schizachyrium scoparium* | ---- | ---- | ---- | 41 | x | ---- | ---- | 33.5 | 3.7 |
| *Schizachyrium littoralis* | 20.7 | 13.8 | 5.7 | --- | ---- | 3.4 | 388.6 | ---- | ---- |
| *Setaria firmula* | 19.8 | 33.4 | 14.0 | --- | x | ---- | ---- | ---- | ---- |
| *Setaria leucopila* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 22.4 |
| *Sorghastrum nutans* | ---- | ---- | ---- | 7 | x | ---- | ---- | ---- | ---- |
| *Sporobolus asper* | ---- | ---- | ---- | 3 | ---- | ---- | ---- | 1.1 | 1.2 |
| *Stipa leucotricha* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 28.5 | 21.5 |
| *Tridens strictus* | ---- | ---- | ---- | 1 | ---- | ---- | ---- | ---- | ---- |
| Other grasses | ---- | 40.4 | 16.9 | --- | ---- | ---- | ---- | ---- | ---- |
| | | | | | | | | | |
| Grasses (% cover) | | | | 78 | | | | | |
| Grasses (relative cover) | 75.8 | | 67.9 | | | 48.6 | | | |
| Grasses ($g/m^2$) | | 162.7 | | | 184.7 | | 488.8 | 165.7 | 235.8 |
| | | | | | | | | | |
| *Carex* spp. | ---- | ---- | ---- | --- | ---- | 7.0 | ---- | ---- | ---- |
| *Fimbristyis puberula* | ---- | ---- | ---- | 3 | ---- | ---- | ---- | ---- | ---- |
| *Rhynchospora* spp. | ---- | ---- | ---- | 1 | ---- | ---- | ---- | ---- | ---- |
| | | | | | | | | | |
| *Acacia hirta* | ---- | ---- | ---- | 1 | ---- | ---- | ---- | ---- | ---- |
| *Acalypha radians* | ---- | ---- | ---- | --- | ---- | ---- | 0.4 | ---- | ---- |
| *Allium* sp. | ---- | ---- | ---- | --- | ---- | ---- | ---- | 0.3 | ---- |
| *Ambrosia psilostachya* | ---- | ---- | ---- | 3 | ---- | ---- | 12.7 | ---- | 4.4 |
| *Aster pratensis* | ---- | ---- | ---- | 1 | ---- | ---- | ---- | ---- | ---- |
| *Baptisia leucophaea* | --- | ---- | ---- | --- | ---- | 3.6 | ---- | ---- | ---- |
| *Commelina erecta* | 0.8 | ---- | ---- | --- | ---- | 3.4 | 2.5 | ---- | ---- |
| *Croton capitatus* | 1.5 | 9.1 | 3.7 | --- | ---- | ---- | ---- | ---- | ---- |
| *Croton dioicus* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 1.2 |
| *Croton punctatus* | ---- | ---- | ---- | --- | ---- | 5.0 | ---- | ---- | ---- |
| *Croton texensis* | ---- | 1.7 | 0.7 | --- | ---- | ---- | ---- | 1.5 | ---- |
| *Erigeron myrionactis* | ---- | ---- | ---- | --- | ---- | 4.4 | ---- | ---- | ---- |
| *Eriogonum multiflorum* | 1.4 | ---- | ---- | --- | ---- | ---- | ---- | ---- | ---- |

Appendix Table C.9 (Cont.)

| Species | Box (1961) Nueces fsl | Drawe & Box (1969) Zavala fsl (g/m²) | Drawe & Box (1969) Zavala fsl (%) | Diamond & Smeins (1984) Alfisols | Bovey et al. (1972) Katy sl | McLendon & DeYoung (1976) | McLendon (2014) Aransas (g/m²) | McLendon (2015) Goliad (g/m²) | McLendon (2015) Karnes (g/m²) |
|---|---|---|---|---|---|---|---|---|---|
| *Eustoma exaltatum* | ---- | ---- | ---- | --- | ---- | 3.9 | ---- | ---- | ---- |
| *Gnaphalium obtusifolium* | ---- | ---- | ---- | --- | ---- | ---- | 1.7 | ---- | ---- |
| *Gutierrezia texana* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 69.8 |
| *Heterotheca subaxillaris* | ---- | 49.8 | 21.3 | --- | ---- | 2.3 | ---- | ---- | ---- |
| *Ibervillea lindheimeri* | ---- | ---- | ---- | --- | ---- | ---- | ---- | 0.5 | ---- |
| *Iva angustifolia* | ---- | ---- | ---- | --- | ---- | ---- | 22.9 | ---- | ---- |
| *Liatris* spp. | ---- | ---- | ---- | 3 | ---- | ---- | ---- | ---- | ---- |
| *Monarda citriodora* | ---- | ---- | ---- | --- | ---- | ---- | 2.4 | ---- | ---- |
| *Nama hispidum* | 6.6 | ---- | ---- | --- | ---- | ---- | ---- | ---- | ---- |
| *Parthenium hysterophorus* | ---- | ---- | ---- | --- | ---- | 3.5 | ---- | ---- | ---- |
| *Phyla incisa* | 0.3 | ---- | ---- | --- | ---- | ---- | 0.7 | ---- | ---- |
| *Physalis viscosa* | ---- | ---- | ---- | --- | ---- | ---- | 1.9 | ---- | ---- |
| *Ratibida columnaris* | ---- | ---- | ---- | 1 | ---- | ---- | 6.3 | ---- | ---- |
| *Rhynchosia americana* | ---- | ---- | ---- | --- | ---- | 2.9 | ---- | ---- | ---- |
| *Rhynchosia texana* | ---- | ---- | ---- | --- | ---- | 4.3 | ---- | ---- | ---- |
| *Sarcostemma cynanchoides* | ---- | ---- | ---- | --- | ---- | ---- | 1.1 | ---- | ---- |
| *Schrankia uncinata* | ---- | ---- | ---- | 3 | ---- | ---- | ---- | ---- | ---- |
| *Sida abutifolia* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 1.3 |
| *Solanum eleagnifolium* | ---- | ---- | ---- | --- | ---- | ---- | ---- | ---- | 0.5 |
| *Tragia urticifolia* | ---- | ---- | ---- | 1 | ---- | ---- | ---- | ---- | ---- |
| *Verbesina enceloides* | 7.8 | 10.0 | 4.0 | --- | ---- | ---- | ---- | ---- | ---- |
| *Verbena halei* | ---- | ---- | ---- | --- | ---- | ---- | 0.7 | ---- | ---- |
| Other forbs | ---- | 5.4 | 2.3 | --- | ---- | ---- | ---- | ---- | 3.5 |
| | | | | | | | | | |
| Forbs (% cover) | ---- | ---- | ---- | 17 | ---- | ---- | ---- | ---- | ---- |
| Forbs (relative cover) | 18.4 | | 32.0 | --- | ---- | 33.3 | ---- | ---- | ---- |
| Forbs (g/m²) | | 76.0 | | --- | 18.5 | ---- | 53.3 | 2.3 | 80.7 |
| | | | | | | | | | |
| Other species | 5.8 | ---- | ---- | --- | ---- | ---- | ---- | ---- | ---- |

Trace species from Diamond and Smeins (1984): *Andropogon gerardii, Aster ericoides, Buchloe dactyloides, Cacalia plantaginea, Carex microdonta, Cirsium undulatum, Eryngium yuccifolium, Hedyotis nigricans, Linum medium, Muhlenbergia capillaris, Oxalis dillenii, Panicum virgatum, Ruellia nudiflora, Sabatia campestris, Scleria ciliata, Silphium laciniatum, Sisyrinchium pruinosum.*

Appendix Table C.10 Mean frequency (%) of plant communities on Pat Welder Ranch, San Patricio County (McLendon and Dahl 1983).

| Species | Mesquite-blackbrush-ragweed | Mesquite-blackbrush-knotroot bristlegrass | Mesquite-blackbrush-huisache | Mesquite-huisache-blackbrush | Mesquite-huisache-buffalograss | MEAN |
|---|---|---|---|---|---|---|
| *Prosopis glandulosa* | 41 | 53 | 37 | 59 | 46 | 47 |
| | | | | | | |
| *Acacia farnesiana* | | | 13 | 15 | 13 | 8 |
| *Acacia rigidula* | 20 | 17 | 33 | 18 | 12 | 20 |
| *Celtis pallida* | | | | 12 | | 2 |
| | | | | | | |
| *Agrostis hiemalis* | | | | | 11 | 2 |
| *Bothriochloa saccharoides* | | 10 | | 11 | | 4 |
| *Buchloe dactyloides* | 10 | | 14 | 15 | 33 | 14 |
| *Chloris verticillata* | | | | 11 | | 2 |
| *Paspalum plicatulum* | | | | 11 | | 2 |
| *Setaria geniculata* | 19 | 61 | 49 | 12 | 10 | 30 |
| *Stipa leucotricha* | | 10 | | 17 | | 3 |
| | | | | | | |
| *Ambrosia psilostachya* | 65 | 79 | 30 | 86 | 23 | 57 |
| *Chamaecrista fasciculata* | | | | 14 | 16 | 6 |
| *Gutierrezia texana* | 25 | 13 | 34 | 29 | 27 | 46 |
| *Sida ciliaris* | 23 | | 18 | 17 | 27 | 17 |
| *Oxalis dillenii* | 10 | | | 35 | 20 | 13 |

Appendix Table C.11 Species composition of available forage (g/m$^2$) on a grazed coastal prairie site (Lake Charles clay), Green Lake Ranch, Calhoun County, Texas, December 1973-April 1974 (Durham and Kothmann 1977).

| Species | 23 Dec | 16 Jan | 13 Feb | 10 Mar | 27 Mar | 10 Apr | Mean |
|---|---|---|---|---|---|---|---|
| *Cynodon dactylon* | 38 | 22 | 33 | 58 | 85 | 58 | 49 |
| *Paspalum lividum* | 19 | 37 | 63 | 91 | 54 | 60 | 54 |
| *Paspalum plicatulum* | 15 | 37 | 31 | 46 | 54 | 36 | 37 |
| *Schizachyrium littoralis* | 105 | 53 | 75 | 73 | 146 | 83 | 89 |
| *Setaria geniculata* | 83 | 31 | 15 | 8 | 8 | 6 | 25 |
| *Sorghastrum nutans* | 31 | 30 | 15 | 31 | 34 | 21 | 27 |
| *Sporobolus indicus* | 45 | 43 | 24 | 22 | 11 | 14 | 27 |
| Other species | 42 | 30 | 15 | 24 | 33 | 13 | 26 |
| | | | | | | | |
| Total Grasses | 378 | 283 | 271 | 353 | 425 | 291 | 334 |

Other grasses: *Bouteloua rigidiseta, Dichanthelium oligosanthes, Panicum virgatum, Paspalum dilatatum.*
The site was dominated by seacoast bluestem and Macartney rose (*Rosa bracteata*).

Appendix Table C.12 Mean aboveground biomass (g/m$^2$) in grazed plots and exclusion plots on a heavily-grazed sandy rangeland in Brooks County, Texas, February-November 1980 (McLendon and Finch, unpublished data). Values are means of 8 plots per treatment per month for 8 months.

| Species | Excluded Animals | | | | | Overall |
|---|---|---|---|---|---|---|
| | None | Cattle | Cattle & Deer | Cattle, Deer, & Rabbits | Cattle, Deer, Rabbits, Gophers | Mean |
| *Acacia greggii* | 0.9 | ---- | ---- | ---- | ---- | 0.2 |
| *Colubrina texensis* | 0.3 | * | ---- | ---- | * | 0.1 |
| *Opuntia leptocaulis* | ---- | ---- | 0.6 | ---- | 1.7 | 0.5 |
| *Opuntia lindheimeri* | 1.5 | 12.5 | ---- | 17.8 | 1.4 | 6.6 |
| *Prosopis glandulosa* | ---- | * | ---- | ---- | ---- | * |
| | | | | | | |
| *Aristida purpurea* | 10.3 | 18.3 | 12.2 | 21.0 | 23.1 | 17.0 |
| *Aristida purpurescens* | 25.8 | 31.8 | 38.9 | 31.8 | 26.1 | 30.9 |
| *Bothriochloa saccharoides* | ---- | ---- | ---- | ---- | 0.5 | 0.1 |
| *Bouteloua hirsuta* | 1.5 | 1.2 | 0.9 | 1.2 | 1.4 | 1.2 |
| *Bracharia ciliatissima* | 2.1 | 2.4 | 4.5 | 4.0 | 5.2 | 3.6 |
| *Cenchrus incertus* | 2.4 | 2.3 | 3.2 | 3.0 | 2.4 | 2.7 |
| *Dichanthelium oligosanthes* | ---- | 0.3 | 0.5 | 0.1 | 1.9 | 0.6 |
| *Digitaria patens* | ---- | ---- | 0.1 | * | ---- | * |
| *Eragrostis secundiflora* | 0.1 | 0.2 | 0.7 | 0.4 | 1.2 | 0.5 |
| *Eragrostis sessilspica* | ---- | ---- | 0.1 | * | ---- | * |
| *Paspalum setaceum* | 11.1 | 10.6 | 16.9 | 13.0 | 10.0 | 12.2 |
| *Setaria firmula* | 4.7 | 7.6 | 5.5 | 2.0 | 5.3 | 5.0 |
| *Sporobolus cryptandrus* | 0.1 | 0.3 | 0.6 | 0.3 | 1.0 | 0.5 |
| | | | | | | |
| *Acalypha radians* | 0.8 | 1.2 | 0.9 | 1.0 | 1.4 | 1.1 |
| *Allium runyoni* | ---- | ---- | ---- | * | * | * |
| *Ambrosia confertifolia* | 2.6 | 7.1 | 6.1 | 5.7 | 3.8 | 5.1 |
| *Aphanostephus kidderi* | 0.1 | 0.1 | 0.3 | * | ---- | 0.1 |
| *Callirhoe involucrata* | 0.1 | 0.3 | ---- | 0.1 | 0.3 | 0.2 |
| *Carex* sp. | ---- | ---- | ---- | * | ---- | * |
| *Centaurium texense* | ---- | * | ---- | ---- | ---- | * |
| *Chamaecrista texana* | 0.5 | 0.2 | 0.2 | 0.5 | 1.5 | 0.6 |
| *Cnidoscolus texanus* | ---- | ---- | ---- | * | ---- | * |
| *Commelina erecta* | 0.7 | 0.3 | 0.2 | 0.4 | 0.4 | 0.4 |
| *Croton argyranthemus* | 1.5 | 1.8 | 3.3 | 2.4 | 1.8 | 2.2 |
| *Croton capitatus* | 7.5 | 3.3 | 2.8 | 3.4 | 3.3 | 4.1 |
| *Eriogonum multiflorum* | * | 1.2 | 0.9 | 0.6 | 0.1 | 0.6 |
| *Evolvulus sericeus* | 0.8 | 0.4 | 0.2 | * | 1.1 | 0.5 |
| *Gaillardia pulchella* | 2.0 | 1.8 | 1.2 | 0.9 | 2.4 | 1.7 |
| *Gaura mckelveyae* | 1.3 | 2.2 | 2.5 | 3.2 | 1.4 | 2.1 |
| *Heterotheca subaxillaris* | 16.2 | 19.6 | 21.4 | 24.1 | 22.2 | 20.7 |
| *Lantana horrida* | 0.1 | 0.2 | 0.6 | ---- | ---- | 0.2 |
| *Lepidium lasiocarpum* | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 |
| *Linum rigidum* | * | * | ---- | ---- | * | * |
| *Monarda punctata* | 19.3 | 26.9 | 28.8 | 25.8 | 37.4 | 27.6 |
| *Oenothera* sp. | ---- | * | ---- | ---- | ---- | * |
| *Oxalis dillenii* | 2.5 | 1.0 | 1.8 | 1.4 | 0.7 | 1.5 |
| *Palafoxia texana* | 7.4 | 9.0 | 7.3 | 3.7 | 8.2 | 7.1 |
| *Phlox drummondii* | 0.5 | ---- | ---- | * | ---- | 0.1 |
| *Physalis cinerascens* | 0.4 | 0.4 | 0.8 | 1.3 | 0.3 | 0.6 |
| *Plantago rhodosperma* | 0.1 | ---- | ---- | ---- | ---- | * |
| *Polygala alba* | ---- | 0.1 | * | ---- | * | * |
| *Ratibida peduncularis* | 2.2 | 2.3 | 2.0 | 1.7 | 2.5 | 2.1 |
| *Rhynchosia americana* | 1.8 | 1.8 | 2.2 | 2.3 | 2.3 | 2.1 |
| *Sida lindheimeri* | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 |
| *Tephrosia lindheimeri* | 6.3 | 7.1 | 2.5 | 8.3 | 4.3 | 5.7 |
| | | | | | | |
| Total Aboveground Biomass | 135.8 | 175.5 | 171.2 | 181.8 | 176.9 | 168.4 |
| Litter | 89.9 | 101.1 | 150.8 | 110.2 | 133.4 | 117.1 |
| | | | | | | |
| Total Shrubs and Cacti | 2.7 | 12.5 | 0.6 | 17.8 | 3.1 | 7.4 |
| Total Grasses | 58.1 | 74.4 | 84.1 | 76.8 | 78.1 | 74.3 |
| Total Forbs | 75.0 | 88.6 | 86.5 | 87.2 | 95.7 | 86.7 |

Dashed lines (----) indicate zero values. Astericks (*) indicate trace (< 0.05 g/m$^2$) amounts.

Appendix Table C.13 Woody plant density (plants/ha) and basal cover ($m^2$/ha) on Miguel and Papalote fine sandy loam soils on La Copita, Jim Wells County (Archer et al. 1988).

| Species | Density: Clusters | Density: Openings | Density: Drainages | Cover Openings | Density of Plants > 2 m in Drainages |
|---|---|---|---|---|---|
| *Acacia farnesiana* | | 70 | 44 | 0.027 | 37 |
| *Aloysia lycioides* | | 0 | 2189 | 0.000 | 0 |
| *Bumelia* spp. | x | 0 | 35 | 0.000 | 9 |
| *Celtis pallida* | x | 0 | 775 | 0.000 | 283 |
| *Colubrina texensis* | | 30 | 582 | 0.001 | 0 |
| *Condalia hookeri* | x | 0 | 462 | 0.000 | 97 |
| *Diospyros texana* | x | 16 | 1101 | 0.001 | 106 |
| *Lantana macropoda* | x | 0 | --- | 0.000 | 0 |
| *Lycium berlandieri* | x | 0 | 197 | 0.000 | 0 |
| *Mahonia trifoliolata* | x | 0 | 39 | 0.000 | 0 |
| *Opuntia lindheimeri* | x | 100 | 982 | ----- | 0 |
| *Opuntia leptocaulis* | x | 30 | --- | ----- | 0 |
| *Prosopis glandulosa* | x | 350 | 764 | 0.022 | 295 |
| *Salvia ballotaeflora* | x | 0 | 339 | 0.000 | 0 |
| *Schaefferia cuneifolia* | x | 0 | 314 | 0.000 | 0 |
| *Yucca treculeana* | | 0 | --- | 0.000 | --- |
| *Zanthoxylum fagara* | x | 30 | 3229 | 0.003 | 318 |
| *Zizyphus obtusifolia* | x | 0 | 218 | 0.000 | 0 |
| TOTALS | | 626 | 11270 | 0.054 | 1145 |

Archer et al. (1988) sites were on Miguel and Papalote fine sandy loams on the La Copita, Jim Wells County. #/ha = number of woody plants per hectare, BC = basal cover (%).
Density of plants > 2 m in drainages included in the values for drainages overall.
Average cluster was 18 $m^2$.
Woody plant coverage averaged 13.0% in 1940 and 36.4% in 1983. This is an annual increase of 0.55 percentage points per year. At that rate, cover in 2013 would be 52.9% (36.4% + 16.5%).

Appendix Table C.14 Woody plant density (plants/ha) and canopy cover ($m^2$/plant) in three plant communities on the Welder Wildlife Refuge, San Patricio County, Texas (Box 1961).

| Species | Density: Mesquite | Density: Chaparral | Density: Prickly pear | Cover: Mesquite | Cover: Chaparral | Cover: Prickly pear |
|---|---|---|---|---|---|---|
| *Acacia farnesiana* | 50 | 39 | 13 | ---- | ---- | ---- |
| *Acacia rigidula* | 3 | 193 | 56 | 11.75 | 3.69 | 0.87 |
| *Acacia tortuosa* | 13 | 34 | 13 | ---- | ---- | ---- |
| *Celtis pallida* | t | 19 | t | ---- | ---- | ---- |
| *Condalia hookeri* | t | 15 | t | ---- | ---- | ---- |
| *Mahonia trifoliolata* | t | 106 | t | ---- | ---- | ---- |
| *Opuntia lindheimeri* | t | t | 426 | ---- | ---- | 4.84 |
| *Prosopis glandulosa* | 364 | 174 | 2046 | 4.84 | 1.28 | 0.74 |
| *Zanthoxylum fagara* | 3 | 39 | 13 | ---- | ---- | ---- |
| *Zizyphus obtusifolia* | 14 | 116 | 56 | ---- | ---- | ---- |
| TOTAL | 447 | 735 | 2623 | | | |

Appendix Table C.15 Vegetation of the Welder Wildlife Refuge, San Patricio County (Drawe et al. 1978).

**Mesquite-mixed grass community: Victoria clay**

Moderate stands of mesquite (12-27% cover), with mottes of mixed brush; huisache is increasing (200-500 trees/ha).
Interspaces with dense stands of grass: 17% Texas wintergrass, 8% meadow dropseed, 2% silver bluestem; little bluestem, plains bristlegrass, Texas cupgrass, lovegrass tridens, sourgrass (*Digitaria insularis*).
Forbs (20%): prairie coneflower, western ragweed, ruellia, horsemint, one-seeded doveweed (*Croton monanthogynus*), bladderpod (*Lesquerella lindheimeri*), Texas broomweed.
Depressions: vine-mesquite, pink tridens, white tridens, frogfruit, water clover (*Marsilea mucronata*).
Swales: hackberry, longtom, sumpweed.

**Chaparral-mixed grass community: drier clay and clay loam sites**

Woody plant cover (34-55%): blackbrush (11%), mesquite, huisache, twisted acacia, agarito, creeping mesquite, granjeno, lotebush, brasil, Texas persimmon, colima. Areas root-plowed 30-35 years ago have brush 2-3 m tall. Mesquite and huisache have increased in height 1.0-1.5 m in 20-25 years and shrubs have increased 0.3-0.5 m.
Understory in mottes: some plains bristlegrass and bunch cutgrass (*Leersia monandra*).
Openings between mottes: similar to mesquite-mixed grass except more silver bluestem and little bluestem.

**Chaparral-mixed grass community: sandy loam sites**

Woody plant cover (25.7%): granjeno, colima, mesquite, huisache, blackbrush, agarito, lotebush, Texas persimmon, prickly pear (0.3%).
Major grasses: silver bluestem, knotroot bristlegrass, plains bristlegrass, Texas cottontop.

**Halophyte-shortgrass community: saline sites adjacent to temporary lakes or swales**

Few, scattered mesquite.
Padre Island dropseed, whorled dropseed, saltgrass, Texas willkommia (*Willkommia texana*), gulf cordgrass, shoregrass; sea oxeye, glasswort (*Salicornia virginica*), purslane, saltbush.

**Paspalum-aquatic plant community: swales on clay soils**

Sesbania and some scattered huisache.
Almost pure stands of hairyseed paspalum (*Paspalum publiflorum*). Some canarygrass (*Phlaris canariensis*), arrowhead, and water clover.
During dry periods, buffalograss and creeping lovegrass (*Neeragrostis reptans*) become abundant.

**Gulf cordgrass community: frequently flooded clay swales**

Upper clay loam sites: mesquite, granjeno, blackbrush, sea oxeye; bermudagrass, little barley
Upper sandy loam sites: huisache; bermudagrass, rescue grass, geranium
Mid-elevation sites: closed canopy of gulf cordgrass
Lower elevation sites: clubhead cutgrass (*Leersia hexandra*), cattail, and spikerush.

**Huisache-mixed grass community:** low swale areas

Dense stands of huisache.
Understory under closed canopy: Texas wintergrass, canarygrass, Ozarkgrass, sixweeks fescue
Understory under open canopy: hairyseed paspalum, knotroot bristlegrass, vine-mesquite
Wetter areas: spiny aster and longtom; drier areas: more silver bluestem, lovegrass tridens, plains bristlegrass.

**Bunchgrass-annual forb community:** sandy and sandy loam soils

Open grassland with 25-40% grass cover. Relative cover = 75% grasses, 19% forbs, 6% shrubs.
Under light grazing: seacoast bluestem, big bluestem, Pan American balsamscale, tanglehead, switchgrass, Texasgrass (*Vaseochloa multinervosa*), trichloris, big sandbur, crinkleawn.
Under moderate grazing: increase in balsamscale and thin paspalum.
Under heavy grazing: sandbur and knotgrass (*Setaria formula*) are common.
Major forbs: skunk daisy (*Ximenesia encelioides*), Texas doveweed, woolly doveweed, wild buckwheat.
On sandy loam sites: increase in sideoats grama, brownseed paspalum, hooded windmillgrass, old-man's beard, and prickly pear.

**Hogplum-bunchgrass community:** sandy loam soils on river terraces

Stands of hogplum and old-man's beard, with scattered huisache and Texas kidneywood.
Hogplum dense on terraces, huisache dense in swales.
Understory: sideoats grama, brownseed paspalum, hooded windmillgrass, prickly pear.

**Huisache-bunchgrass community:** lower areas of Odem sandy loam soils

Moderate to dense stands of huisache and dense stands of old-man's beard.
Understory similar to bunchgrass-annual forb community, but with southwestern bristlegrass (*Setaria scheelei*), Texas wintergrass, Virginia wildrye, snoutbean, and ruellia.

**Chittimwood-hackberry community:** sandy loam soils

Dense stands of chittimwood (*Bumelia lanuginosa*) and hackberry. Small trees (3-7 m tall), with canopies extending to near the ground.
Sparse understory: southwestern bristlegrass and Turk's cap (*Malvavicus drummondii*).

**Live oak-chaparral community:** sandy and sandy loam soils

Overstory: scattered stands of old live oak, 2% canopy cover.
Mid-level: mesquite (30%; 3-5 m tall), colima (14%), Texas persimmon (6%), blackbrush (6%), granjeno (5%), agarito (5%), chittimwood, hackberry, anacua, chapatillo (*Amyris texana*), tickle-tongue.
Understory: seacoast bluestem, brownseed paspalum, tanglehead; some big bluestem, switchgrass, indiangrass, trichloris, southwestern bristlegrass.
Heavier grazing: windmillgrasses, brownseed paspalum, thin paspalum, sandbur.
Turk's cap, pigeon berry (*Rivina humilis*), mistflower, skunk daisy, doveweed.

**Mesquite-bristlegrass community:** poorly-drained sands and sandy loams

Open stands of mesquite, with granjeno, colima, lotebush, agarito.
Understory: knotroot bristlegrass, brownseed paspalum, Hall panicum, silver bluestem, gummy lovegrass; western ragweed

**Riparian woodland community:** riparian bottomlands

Stands of large trees: hackberry, anacua, cedar elm, pecan, with mustang grape.
Shrub understory: similar to that of live oak-chaparral community.
Herbaceous understory: southwestern bristlegrass, broadleaf uniola (*Chasmanthium latifolium*), Virginia wildrye, Turk's cap, velvet mallow (*Wissadula amplissima*).

**Woodland-spiny aster community:** mixed alluvial soils

Mixture of chaparral, western soapberry (*Sapindus saponaria*), and spiny aster.

**Spiny aster-longtom community:** low-lying areas where water stands for long periods following rains

Dense stands of spiny aster, with some longtom and little snoutbean (*Rhynchosia minima*).

**Lakes and Ponds**

Submersed community: coontail (*Ceratophyllum demersum*), water nymph (*Najas quadalupensis*), water stargrass (*Heteranthera liebmanni*), wigeongrass (*Ruppia maritima*), sago pondweed (*Potamogeton pectinatus*), and muskgrass (*Chara* spp.).
Floating community: mostly lotus (*Nelumbo lutea*).
Lower marsh edges: bulrushes (*Scirpus* spp.), cattails, and sedges.
Upper marsh edges: clubhead cutgrass, longtom, sesbania.
As ponds dry: buffalograss, knotroot bristlegrass, creeping lovegrass.

Appendix Table C.16 Woody plants reported on other study sites in South Texas.

| Species | Campbellton Bovey et al. 1970 | Webb Co. Buckley & Dodd 1969 | Goliad Co. Dodd & Holtz 1972 |
|---|---|---|---|
| *Acacia farnesiana* | major | | |
| *Acacia greggii* | scattered | | |
| *Acacia rigidula* | major | | 308/ha |
| *Celtis pallida* | scattered | | |
| *Colubrina texensis* | scattered | | 185/ha |
| *Diospyros texana* | scattered | | 124/ha |
| *Eysenhardtia texana* | scattered | | |
| *Lycium berlandieri* | scattered | | |
| *Mahonia trifoliolata* | scattered | | 62/ha |
| *Opuntia leptocaulis* | scattered | | |
| *Opuntia linheimeri* | scattered | density = 1 | |
| *Parkinsonia aculeata* | | density = 4 | |
| *Prosopis glandulosa* | scattered | density = 3 | |
| *Varilla texana* | | density = 2 | |
| *Yucca treculeana* | scattered | | |
| *Zizyphus obtusifolia* | scattered | | 62/ha |
| Other woody species | | | 333/ha |

Appendix Table C.17 Woody plant cover (%) at sites in South Texas.

| Community | Woody Cover | Location | Reference |
|---|---|---|---|
| Blackbrush-mesquite | 20.4 | Welder WR, San Patricio Co. | Box (1961) |
| Blackbrush-mesquite | 38.4 | Welder WR, San Patricio Co. | Drawe et al. (1978) |
| Blackbrush-mesquite | 48.6 | Welder WR, San Patricio Co. | Powell & Box (1967) |
| Granjeno-colima | 25.7 | Welder WR, San Patricio Co. | Drawe et al. (1978) |
| Mesquite-buffalograss | 18.6 | Welder WR, San Patricio Co. | Box (1961) |
| Mesquite-huisache | 47 | Welder WR, San Patricio Co. | Box & White (1969) |
| Mesquite-mixed grass | 20 | Welder WR, San Patricio Co. | Drawe et al. (1978) |
| Mesquite-prickly pear | 36.4 | La Copita, Jim Wells Co. | Archer et al. (1988) |
| Prickly pear-mesquite | 39.4 | Welder WR, San Patricio Co. | Box (1961) |

Appendix Table C.18 Species composition (%) in wetland communities on the Welder Wildlife Refuge, San Patricio County (Scifres et al. 1980).

| Species | Clubhead cutgrass | Cattail-cutgrass | Cutgrass-spikerush | Cutgrass-longtom | Wetland Mean | Gulf cordgrass |
|---|---|---|---|---|---|---|
| *Borrichia frutescens* | 0 | 1 | t | 0 | t | 2 |
| | | | | | | |
| *Cynodon dactylon* | 2 | 5 | t | 5 | 3 | t |
| *Leersia hexandra* | 29 | 19 | 28 | 20 | 24 | 3 |
| *Paspalum lividum* | 20 | 14 | 14 | 29 | 19 | 4 |
| *Setaria geniculata* | 0 | 0 | 7 | t | 2 | 3 |
| *Spartina spartinae* | 0 | 0 | t | t | t | 65 |
| | | | | | | |
| *Echinodorus cordifolius* | 9 | 4 | 6 | 7 | 6 | 2 |
| *Eleocharis spp* | 16 | 10 | 19 | 11 | 14 | 6 |
| *Fimbristylis castanea* | 6 | 5 | 8 | 3 | 5 | 5 |
| *Typha domingensis* | t | 32 | t | 0 | 8 | 0 |
| | | | | | | |
| *Iva annua* | 0 | 0 | 0 | 6 | 2 | 0 |
| *Phyla incisa* | t | t | 6 | t | 2 | t |
| *Polygonum ramosissimum* | 0 | 0 | 2 | 7 | 2 | 1 |
| *Rumex crispus* | 4 | 1 | 2 | 9 | 2 | 4 |
| *Sagittaria latifolia* | 4 | 3 | 3 | 1 | 3 | 4 |

Appendix Table C.19 Non-quantified species lists for South Texas plant communities.

| Species | Drawe (1994) Bluestem-cordgrass | McLendon (1994) Mesquite-granjeno-acacia | Smeins (1994a) Little bluestem-indiangrass | Smeins (1994b) Little bluestem-post oak | Archer (1990) La Copita Jim Wells Co. |
|---|---|---|---|---|---|
| *Acacia farnesiana* | | common | | | |
| *Acacia rigidula* | | common | | | |
| *Acacia tortuosa* | | common | | | |
| *Aloysia lycioides* | | common | | | |
| *Celtis laevigata* | | | | common | |
| *Celtis pallida* | | sub-dominant | | | common |
| *Condalia hookeri* | | common | | | common |
| *Diospyros texana* | | common | | | common |
| *Mahonia trifoliolata* | | common | | | common |
| *Opuntia linheimeri* | | common | | | |
| *Porlieria angustifolia* | | common | | | |
| *Prosopis glandulosa* | | dominant | | | dominant |
| *Quercus buckleyi* | | | | common | |
| *Quercus marilandica* | | | | common | |
| *Quercus stellata* | | | | dominant | |
| *Quercus virginiana* | | | | common | |
| *Rhus aromatic* | | | | common | |
| *Schaefferia cuneifolia* | | | | | common |
| *Smilax bona-nox* | | | | common | |
| *Symphoricarpos orbiculatus* | | | | common | |
| *Zanthoxylum fagara* | | common | | | common |
| *Zizyphus obtusifolia* | | common | | | common |
| | | | | | |
| *Andropogon gerardii* | | | | common | |
| *Andropogon glomeratus* | common | | | | |
| *Andropogon tenarius* | common | | | | |
| *Andropogon virginicus* | common | | | | |
| *Aristida purpurea* | common | common | common | common | common |
| *Bothriochloa saccharoides* | common | common | | | |
| *Bouteloua curtipendula* | | common | common | common | |
| *Bouteloua hirsuta* | | common | common | common | |
| *Bouteloua rigidiseta* | | common | common | | common |
| *Bouteloua trifida* | | common | | | common |
| *Buchloe dactyloides* | common | common | common | common | |
| *Cenchrus ciliaris* | | common | | | |
| *Cenchrus incertus* | | common | | | common |
| *Chloris cucullata* | | common | | | common |
| *Chloris pluriflora* | | common | | | |
| *Dichanthium annulatum* | | common | | | |
| *Distichlis spicata* | common | | | | |
| *Elyonurus tripsacoides* | common | | | | |
| *Hilaria belangeri* | | common | | | |
| *Panicum obtusum* | | common | | | |
| *Pappophorum bicolor* | | common | | | |
| *Paspalum plicatulum* | common | | | | |
| *Paspalum lividum* | common | | | | |
| *Paspalum setaceum* | | | | | common |
| *Schizachyrium littoralis* | dominant | | | | |
| *Schizachyrium scoparium* | dominant | | dominant | sub-dominant | |
| *Setaria leucopila* | | common | | | |
| *Setaria texana* | | common | | | |
| *Sorghastrum nutans* | | | sub-dominant | common | |
| *Spartina spartinae* | dominant | | | | |
| *Sporobolus asper* | common | | common | common | |
| *Sporobolus indicus* | common | | | | |
| *Sporobolus tharpii* | common | | | | |
| *Stipa leucotricha* | common | | common | common | |
| *Tridens congestus* | common | | | | |
| | | | | | |
| *Carex* spp. | common | | | | |
| *Eleocharis* spp. | common | | | | |
| *Fimbristylis* spp. | common | | | | |
| *Scirpus* spp. | common | | | | |

Appendix Table C.19 (Cont.)

| Species | Drawe (1994) Bluestem-Cordgrass | McLendon (1994) Mesquite-granjeno-acacia | Smeins (1994a) Little bluestem-indiangrass | Smeins (1994b) Little bluestem-post oak | Archer (1990) La Copita Jim Wells Co. |
|---|---|---|---|---|---|
| *Ambrosia psilostachya* | common | | | | |
| *Amphiachyris dracunculoides* | | common | | | |
| *Clematis drummondii* | | common | | | |
| *Croton* spp. | common | common | | | |
| *Cynanchum leave* | | common | | | |
| *Desmanthus virgatus* | | common | | | |
| *Dichondra micrantha* | common | | | | |
| *Ericameria texana* | | common | | | |
| *Eriogonum multiflorum* | common | | | | |
| *Eupatorium odoratum* | | common | | | common |
| *Eupatorium incarnatum* | | common | | | common |
| *Evolvulus* spp. | | | | | common |
| *Gnaphalium obtusifolium* | | common | | | |
| *Iva annua* | common | | | | |
| *Lantana horrida* | | common | | | |
| *Parietaria texana* | | common | | | |
| *Parthenium incanatum* | | common | | | |
| *Ratibida columnaris* | common | | | | |
| *Rhynchosia* spp. | common | | | | |
| *Sagittaria latifolia* | common | | | | |
| *Sarcostemma cynanchoides* | | common | | | |
| *Verbesina* spp. | | | | | common |
| *Zexmenia hispida* | | common | | | common |

Remnants of the bluestem-cordgrass prairie remain as the Goliad Prairie, McFaddin Prairie (near Victoria), and east of Tivoli (Drawe 1994).

Appendix Table C.20 Effect of range condition or seral stage on forage production.

| Type | Location | Units | Excellent | Good | Fair | Poor | Reference |
|---|---|---|---|---|---|---|---|
| Bluestem prairie | LA | lbs/ac | 2828 | 3239 | 3351 | | Duvall & Linnartz (1967) |
| Bluestem prairie | OK | lbs/ac | 3767 | | | 3172 | Hazell (1967) |
| Bluestem prairie | NE | % comp | 83 | 46 | 11 | | Jensen & Schumacher (1969) |
| Bluestem prairie | TX | $g/m^2$ | 489 | | | | McLendon (2014): Aransas NWR |
| Bluestem prairie | TX | $g/m^2$ | | | 236 | | McLendon (2015): Stieren Ranch |
| Bluestem prairie | TX | $g/m^2$ | | | 208 | | McLendon et al. (2001): Fort Hood |
| Bluestem prairie | TX | $g/m^2$ | | | | 176 | McLendon (unpublished): Brooks Co. |
| Bluestem prairie | TX | $g/m^2$ | | | | 163 | Drawe & Box (1969): Welder WR |
| Bluestem prairie | TX | $g/m^2$ | | | | 172 | McLendon (1977): Dimmit County |

Appendix Table C.21 Effect of grazing intensity on forage production.

| Type | Location | Units | Ungrazed | Light | Medium | Heavy | Reference |
|---|---|---|---|---|---|---|---|
| Black grama grassland | NM | basal | 0.73 | 1.00 | 0.69 | 0.57 | Paulsen & Ares 1962 |
| Tobosa grassland | NM | basal | 0.51 | 1.00 | 1.09 | 0.94 | Paulsen & Ares 1962 |
| Blue grama stony hills | NM | $g/m^2$ | 62.7 | | 52.6 | | Pieper 1968 |
| Blue grama loam upland | NM | $g/m^2$ | 72.8 | | 61.6 | | Pieper 1968 |
| Blue grama bottomland | NM | $g/m^2$ | 68.3 | | 18.0 | | Pieper 1968 |

Appendix Table C.22 Calculation of change in aboveground grass biomass with change in range condition, seral stage, or grazing intensity. Ratios based on data in Appendix Tables C.20 and C.21.

```
Bluestem prairie   LA   Good = 1.15(Excellent)  Fair = 1.18(Excellent)
Bluestem prairie   OK                                                  Poor = 0.84(Excellent)
Bluestem prairie   NE   Good = 0.55(Excellent)  Fair = 0.13(Excellent)
Bluestem prairie   TX                           Fair = 0.45(Excellent)  Poor = 0.35(Excellent)

Tobosa grassland   NM   Light = 1.96(Ungrazed)  Medium = 2.14(Ungrazed)  Heavy = 1.84(Ungrazed)
Black grama        NM   Light = 1.37(Ungrazed)  Medium = 0.95(Ungrazed)  Heavy = 0.78(Ungrazed)
Blue grama         NM                           Medium = 0.64(Ungrazed)


Means:           Good = 0.85(Excellent)   Fair = 0.59(Excellent)   Poor = 0.60(Excellent)
          Light = 1.67(Ungrazed)    Medium = 1.25(Ungrazed)    Heavy = 1.31(Ungrazed)
                              Medium = 0.75(Light)        Heavy = 0.78(Light)

Summary:                       1.00 ----> 0.85 ----> 0.75 ----> 0.59 ----> 0.69

      Range Condition:      Excellent     Good    High-Fair   Low-Fair     Poor
      Seral Stage:            Late             Mid                        Early
      Grazing Intensity:      Light          Moderate              Heavy
```

Appendix Table C.23 Aboveground biomass ($g/m^2$) for woody species in the Victoria County EDYS model (values based on 100% canopy cover of the respective woody species).

| Species | Common Name | Trunk | Stems | Leaves | Total |
|---|---|---|---|---|---|
| *Acacia farnesiana* | huisache | 5,000 | 1,460 | 260 | 6,720 |
| *Carya illinioensis* | pecan | 23,650 | 3,890 | 330 | 27,870 |
| *Celtis laevigata* | sugar hackberry | 11,820 | 1,950 | 330 | 14,100 |
| *Prosopis glandulosa* | mesquite | 7,240 | 1,000 | 300 | 8,540 |
| *Quercus stellata* | post oak | 12,240 | 1,920 | 190 | 14,350 |
| *Quercus virginiana* | live oak | 24,270 | 3,830 | 380 | 28,480 |
| | | | | | |
| *Acacia rigidula* | blackbrush | 630 | 1,300 | 440 | 2,370 |
| *Baccharis texana* | prairie baccharis | 1,240 | 1,240 | 260 | 2,740 |
| *Borrichia frutescens* | sea oxeye | 150 | 100 | 250 | 500 |
| *Celtis pallida* | granjeno | 1,060 | 1,070 | 350 | 2,480 |
| *Lycium berlandieri* | wolfberry | 810 | 810 | 250 | 1,870 |
| *Rosa bracteata* | Macartney rose | 1,200 | 3,600 | 900 | 5,700 |
| *Sesbania drummondii* | rattlepod | 250 | 1,000 | 100 | 1,350 |
| | | | | | |
| *Vitis mustangensis* | mustang grape | 1,200 | 200 | 400 | 1,800 |
| | | | | | |
| *Opuntia lindheimeri* | prickly pear | 350 | 2,000 | 10 | 2,360 |

Appendix Table C.24 Effect of woody cover on grass production on two rangelands in Texas.

| | Mesquite Canopy (%) | | | | Huisache Canopy (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2-3** | **7-8** | **13** | **24** | **00** | **10** | **20** | **30** | **40** | **50** | **60** | **70** |
| Production ($g/m^2$): | 126 | 135 | 145 | 96 | 415 | 425 | 365 | 320 | 290 | 235 | 190 | 135 |
| Proportion of lowest: | 1.00 | 1.07 | 1.15 | 0.76 | 1.00 | 1.02 | 0.88 | 0.77 | 0.70 | 0.57 | 0.46 | 0.33 |

Mesquite = Rolling Plains near Vernon (McDaniel et al. 1982); huisache = Welder Wildlife Refuge, San Patricio County (Scrifes et al. 1982).
Approximate grass production = (amount at 0% cover)[1.00 – (0.8)(woody plant cover)].

Appendix Table C.25. Species composition and initial biomass values for land-use types in the Victoria County EDYS model. Values for woody species are in % of total woody cover and impervious surfaces are % of total area. Values for herbaceous species are $g/m^2$.

| Species | Urban Houses | Buildings Industrial | Disturbed Areas | Caliche Pits | Tilled Fields | Orchard |
|---|---|---|---|---|---|---|
| Huisache | --- | 30 | 30 | 10 | 30 | --- |
| Pecan | 5 | --- | --- | --- | --- | 100 |
| Hackberry | --- | 30 | 20 | --- | 20 | --- |
| Mesquite | 40 | 20 | 30 | 20 | 30 | --- |
| Live oak | 55 | --- | --- | --- | --- | --- |
| Blackbrush | --- | --- | --- | 30 | --- | --- |
| Baccharis | --- | 20 | 10 | 10 | 10 | --- |
| Granjeno | --- | --- | 10 | 20 | 10 | --- |
| Purple threeawn | --- | 20 | 25 | 20 | 25 | --- |
| Silver bluestem | --- | 10 | 5 | --- | --- | --- |
| Sideoats grama | --- | 10 | --- | 20 | --- | --- |
| Buffalograss | --- | 50 | --- | 10 | --- | --- |
| Sandbur | --- | 10 | 10 | 10 | 10 | --- |
| Hooded windmillgrass | --- | 10 | 10 | 20 | 10 | --- |
| Bermudagrass | 500 | 100 | 10 | 10 | 10 | 50 |
| Knotroot bristlegrass | --- | --- | 20 | --- | --- | --- |
| Johnsongrass | --- | 150 | 20 | 10 | 20 | 20 |
| Milo | --- | --- | --- | --- | 20 | --- |
| Ragweed | --- | 50 | 20 | 20 | 20 | 10 |
| Sunflower | --- | 50 | 20 | 10 | 20 | 10 |
| Impervious surface | 50% | 90% | 0% | 10% | 0% | 0% |

Appendix Table C.26 Species composition and aboveground herbaceous production (clippable biomass) in improved pasture by soil series in Victoria County.

| NRCS Range Site | Woody Species Relative Composition (%) | Herbaceous Species Initial Aboveground Biomass (g/m$^2$) BOIS | CYDA | PACO | SOHA | AMPS |
|---|---|---|---|---|---|---|
| **Clay Soils** | | | | | | |
| Blackland | huisache 50; Macart rose 40; mesquite 10 | 127 | 0 | 1042 | 63 | 35 |
| Clayey Bottomland | huisache 60; Macart rose 30; hackberry 10 | 94 | 0 | 694 | 47 | 100 |
| Loamy Bottomland | huisache 60; Macart rose 30; hackberry 10 | 98 | 0 | 831 | 49 | 67 |
| **Clay Loam and Loam Soils** | | | | | | |
| Clay Loam | huisache 60; Macart rose 30; mesquite 10 | 67 | 0 | 571 | 34 | 27 |
| Rolling Blackland | huisache 50; mesquite 30; Macart rose 20 | 60 | 0 | 510 | 30 | 22 |
| Gray Sandy Loam | huisache 60; mesquite 30; granjeno 10 | 41 | 0 | 370 | 21 | 24 |
| **Sandy Loam Soils** | | | | | | |
| Claypan Prairie | huisache 50; McCart rose 30; mesquite 20 | 55 | 464 | 0 | 28 | 51 |
| Loamy Prairie | huisache 50; McCart rose 30; mesquite 20 | 95 | 804 | 0 | 47 | 45 |
| Sandy Loam | huisache 50; mesquite 40; hackberry 10 | 61 | 518 | 0 | 30 | 39 |
| Tight Sandy Loam | huisache 50; mesquite 30; hackberry 20 | 65 | 555 | 0 | 33 | 39 |
| **Sandy Soils** | | | | | | |
| Deep Sand | huisache 20; mesquite 40; live oak 40 | 36 | 307 | 0 | 18 | 19 |
| Loamy Sand | huisache 30; mesquite 50; live oak 20 | 21 | 177 | 0 | 10 | 21 |
| Sandy Prairie | huisache 40; mesquite 50; live oak 10 | 95 | 804 | 0 | 47 | 46 |
| Sandy Bottomland | huisache 20; mesquite 40; hackberry 40 | 31 | 264 | 0 | 16 | 26 |
| **Shallow Soils** | | | | | | |
| Gravelly | huisache 20; mesquite 50; baccharis 30 | 35 | 301 | 0 | 18 | 16 |
| Shallow | huisache 10; mesquite 40; blackbrush 50 | 22 | 191 | 0 | 11 | 22 |
| **Wetland Soils** | | | | | | |
| Salty Bottomland | huisache 90; mesquite 10 | 56 | 471 | 0 | 28 | 50 |

BOIS = King Ranch bluestem; CYDA = bermudagrass; PACO = kleingrass; SOHA = Johnsongrass; AMPS = ragweed.
Annual aboveground production (g/m$^2$) of three forage species, adjusted to mean annual precipitation for Victoria County (36.7 inches), are 608 for bermudagrass, 838 for kleingrass, and 914 for King Ranch bluestem (McCawley 1978, Kapinga 1982) on Orelia fine sandy loam soils. Compared to production from native species (sandy loam = 549 g/m$^2$), there are 1.11 for bermudagrass, 1.53 for kleingrass, and 1.67 for King Ranch bluestem. Total forage biomass of improved pastures was estimated by multiplying these respective factors by total grass production under excellent range condition (Table C.2).
Major improved pasture species are assumed to be determined by soil texture and soil depth: clays and clay loams = kleingrass; sands, sandy loams, shallow soils, and wetlands = bermudagrass. King Ranch bluestem is considered to constitute 10% of the forage biomass and Johnsongrass 5% on all improved pastures. Ragweed was set equal to total forb biomass under late-seral conditions.

Appendix Table C.27 Initial vegetation plot types, including separation by woody plant coverage (%), used in the Victoria County EDYS model.

| Plot Type | Range Type | Woody Coverage | Number of Cells | Plot Type | Range Type | Woody Coverage | Number of Cells |
|---|---|---|---|---|---|---|---|
| 32 | Blackland | 0-1 | 15752 | 74 | Loamy Prairie | 0-1 | 1917 |
| 33 | Blackland | 1-10 | 4555 | 75 | Loamy Prairie | 1-10 | 79 |
| 34 | Blackland | 10-25 | 900 | 76 | Loamy Prairie | 10-25 | 622 |
| 35 | Blackland | 25-50 | 3733 | 77 | Loamy Prairie | 25-50 | 17 |
| 36 | Blackland | 50-75 | 2029 | 78 | Loamy Prairie | 50-75 | 318 |
| 37 | Blackland | 75-90 | 5396 | 79 | Loamy Prairie | 75-90 | 786 |
| 38 | Blackland | 90-100 | 3180 | 80 | Loamy Prairie | 90-100 | 24857 |
| 100 | Clay Loam | 1-10 | 1335 | 39 | Loamy Sand | 1-10 | 11336 |
| 101 | Clay Loam | 10-25 | 374 | 40 | Loamy Sand | 10-25 | 9837 |
| 102 | Clay Loam | 25-50 | 1400 | 41 | Loamy Sand | 25-50 | 6383 |
| 103 | Clay Loam | 50-75 | 574 | 42 | Loamy Sand | 50-75 | 22289 |
| 104 | Clay Loam | 75-90 | 2087 | 43 | Loamy Sand | 75-90 | 1497 |
| 105 | Clay Loam | 90-100 | 127 | | | | |
| | | | | 07 | Rolling Blackland | 1-10 | 19492 |
| 87 | Clayey Bottomland | 0-1 | 4562 | 08 | Rolling Blackland | 10-25 | 24624 |
| 88 | Clayey Bottomland | 1-10 | 7537 | 09 | Rolling Blackland | 25-50 | 19090 |
| 89 | Clayey Bottomland | 10-25 | 184 | 10 | Rolling Blackland | 50-75 | 10471 |
| 90 | Clayey Bottomland | 25-50 | 19915 | 11 | Rolling Blackland | 75-90 | 2995 |
| 91 | Clayey Bottomland | 50-75 | 197146 | 12 | Rolling Blackland | 90-100 | 2846 |
| 92 | Clayey Bottomland | 75-90 | 259 | | | | |
| 93 | Clayey Bottomland | 90-100 | 1 | 64 | Salt Marsh | 1-10 | 5166 |
| | | | | 65 | Salt Marsh | 10-25 | 2308 |
| 51 | Claypan Prairie | 0-1 | 211 | 66 | Salt Marsh | 50-75 | 1455 |
| 52 | Claypan Prairie | 1-10 | 10 | 67 | Salt Marsh | 75-90 | 2775 |
| 53 | Claypan Prairie | 10-25 | 97 | | | | |
| 54 | Claypan Prairie | 25-50 | 78 | 01 | Salty Bottomland | 1-10 | 3553 |
| 55 | Claypan Prairie | 50-75 | 18 | 02 | Salty Bottomland | 10-25 | 2361 |
| 56 | Claypan Prairie | 75-90 | 49 | 03 | Salty Bottomland | 25-50 | 74 |
| 57 | Claypan Prairie | 90-100 | 10669 | 04 | Salty Bottomland | 50-75 | 17 |
| | | | | 05 | Salty Bottomland | 75-90 | 111 |
| 26 | Deep Sand | 1-10 | 82 | 06 | Salty Bottomland | 90-100 | 1 |
| 27 | Deep Sand | 10-25 | 2640 | | | | |
| 28 | Deep Sand | 25-50 | 1272 | 106 | Sandy Bottomland | 1-10 | 1825 |
| 29 | Deep Sand | 50-75 | 43 | 107 | Sandy Bottomland | 10-25 | 764 |
| 30 | Deep Sand | 75-90 | 3341 | 108 | Sandy Bottomland | 25-50 | 363 |
| 31 | Deep Sand | 90-100 | 10849 | 109 | Sandy Bottomland | 50-75 | 68 |
| | | | | 110 | Sandy Bottomland | 75-90 | 431 |
| 81 | Gravelly | 1-10 | 2889 | 111 | Sandy Bottomland | 90-100 | 159 |
| 82 | Gravelly | 10-25 | 6418 | | | | |
| 83 | Gravelly | 25-50 | 3112 | 20 | Sandy Loam | 1-10 | 53136 |
| 84 | Gravelly | 50-75 | 2556 | 21 | Sandy Loam | 10-25 | 556 |
| 85 | Gravelly | 75-90 | 1196 | 22 | Sandy Loam | 25-50 | 125593 |
| 86 | Gravelly | 90-100 | 64 | 23 | Sandy Loam | 50-75 | 29807 |
| | | | | 24 | Sandy Loam | 75-90 | 33902 |
| 68 | Gray Sandy Loam | 1-10 | 23948 | 25 | Sandy Loam | 90-100 | 19773 |
| 69 | Gray Sandy Loam | 10-25 | 2132 | | | | |
| 70 | Gray Sandy Loam | 25-50 | 25033 | 13 | Sandy Prairie | 1-10 | 351 |
| 71 | Gray Sandy Loam | 50-75 | 22948 | 14 | Sandy Prairie | 10-25 | 313 |
| 72 | Gray Sandy Loam | 75-90 | 39853 | 16 | Sandy Prairie | 50-75 | 1185 |
| 73 | Gray Sandy Loam | 90-100 | 39936 | 17 | Sandy Prairie | 75-90 | 1393 |
| | | | | 18 | Sandy Prairie | 90-100 | 2212 |
| 44 | Loamy Bottomland | 0-1 | 89579 | | | | |
| 45 | Loamy Bottomland | 1-10 | 47924 | 95 | Shallow | 10-25 | 1134 |
| 46 | Loamy Bottomland | 10-25 | 36380 | 96 | Shallow | 25-50 | 65 |
| 47 | Loamy Bottomland | 25-50 | 23344 | 97 | Shallow | 50-75 | 7726 |
| 48 | Loamy Bottomland | 50-75 | 39054 | 98 | Shallow | 75-90 | 2871 |
| 49 | Loamy Bottomland | 75-90 | 18970 | 99 | Shallow | 90-100 | 483 |
| 50 | Loamy Bottomland | 90-100 | 30 | | | | |

Appendix Table C.27 (Cont.)

| Plot Type | Range Type | Woody Coverage | Number of Cells | Plot Type | Range Type | Woody Coverage | Number of Cells |
|---|---|---|---|---|---|---|---|
| 58 | Tight Sandy Loam | 1-10 | 10570 | 61 | Tight Sandy Loam | 50-75 | 14169 |
| 59 | Tight Sandy Loam | 10-25 | 930 | 62 | Tight Sandy Loam | 75-90 | 385 |
| 60 | Tight Sandy Loam | 25-50 | 1430 | 63 | Tight Sandy Loam | 90-100 | 439 |

Appendix Table C.28 Weighted mean woody plant cover (%) by plot type and overall used as initial input values into the Victoria County EDYS model. Means are weighted by area (number of cells) in each woody coverage category.

| Range Type | Number of Cells | (Number of Cells)(Woody Coverage) | Mean Woody Cover |
|---|---|---|---|
| Blackland | 35,545 | 10,743.76 | 30.23 |
| Clay Loam | 5,897 | 2,880.55 | 48.85 |
| Clayey Bottomland | 229,604 | 132,441.19 | 57.68 |
| Claypan Prairie | 11,132 | 10,237.27 | 91.96 |
| Deep Sand | 18,227 | 14,069.33 | 77.19 |
| Gravelly | 16,235 | 5,146.01 | 31.70 |
| Gray Sandy Loam | 153,850 | 96,568.13 | 62.77 |
| Loamy Bottomland | 255,281 | 59,088.73 | 23.15 |
| Loamy Prairie | 28,596 | 24,608.41 | 86.06 |
| Loamy Sand | 51,342 | 20,047.58 | 39.05 |
| Rolling Blackland | 79,518 | 24,447.40 | 30.74 |
| Salt Marsh | 11,704 | 3,893.64 | 33.27 |
| Salty Bottomland | 6,117 | 734.54 | 12.01 |
| Sandy Bottomland | 3,610 | 918.33 | 25.44 |
| Sandy Loam | 262,809 | 116,184.06 | 44.21 |
| Sandy Prairie | 9,819 | 5,736.73 | 58.42 |
| Shallow | 12,596 | 7,953.83 | 63.15 |
| Tight Sandy Loam | 27,923 | 10,902.37 | 39.04 |
| Total Rangelands | 1,219,805 | 546,601.86 | |
| Rangeland Weighted Mean | | | 44.81 |
| Disturbed Sites | 58,133 | 18,498.86 | 31.82 |
| Orchards | 2,350 | 537.81 | 22.89 |
| Housing | 19,942 | 10,806.83 | 54.19 |
| Industrial | 6,456 | 1,354.78 | 20.98 |
| Mine Pits | 129,220 | 12,087.15 | 9.35 |
| Cultivated | 2,574 | 216.72 | 8.42 |
| Total Non-Rangeland | 218,675 | 43,502.15 | |
| Non-Range Weighted Mean | | | 19.89 |
| County-Wide Total | 1,438,480 | 590,104.01 | 41.02 |

Appendix Table C.29 Forage consumption (C; g/m$^2$) by cattle on a seacoast bluestem-Macartney rose pasture in Calhoun County, Texas. Values are from utilization (U; %) x available forage (F; g/m$^2$). Data taken from Durham and Kothmann (1977).

| Species | Dec 22 | | | Jan 14 | | | Feb 11 | | | Mar 08 | | | Mar 25 | | | Apr 08 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | U | F | C | U | F | C | U | F | C | U | F | C | U | F | C | U | F | C |
| Macartney rose | 6 | 101 | 6.1 | 9 | 44 | 4.0 | 6 | 94 | 5.8 | 5 | 36 | 1.8 | 2 | 90 | 1.8 | 0 | -- | 1.3 |
| Bermudagrass | 35 | 38 | 13.3 | 31 | 22 | 6.8 | 40 | 33 | 13.2 | 27 | 58 | 15.7 | 20 | 85 | 17.0 | 31 | 58 | 18.0 |
| Longtom | 15 | 19 | 2.9 | 33 | 37 | 12.2 | 32 | 63 | 20.2 | 25 | 91 | 22.8 | 22 | 54 | 11.9 | 11 | 60 | 6.6 |
| Brownseed paspalum | 28 | 15 | 4.2 | 26 | 37 | 9.6 | 38 | 31 | 11.8 | 25 | 46 | 11.5 | 17 | 54 | 9.2 | 14 | 36 | 5.0 |
| Seacoast bluestem | 10 | 105 | 10.5 | 16 | 53 | 8.5 | 29 | 75 | 21.8 | 22 | 73 | 16.1 | 22 | 146 | 32.1 | 24 | 83 | 19.9 |
| Knotroot bristle | 12 | 83 | 10.0 | 3 | 31 | 0.9 | 30 | 15 | 4.5 | 24 | 8 | 1.9 | 27 | 8 | 2.2 | 40 | 6 | 2.4 |
| Indiangrass | 7 | 31 | 2.2 | 4 | 30 | 1.2 | 25 | 15 | 3.8 | 18 | 31 | 5.6 | 14 | 34 | 4.8 | 33 | 21 | 7.0 |
| Smutgrass | 37 | 45 | 16.7 | 44 | 43 | 18.9 | 55 | 24 | 13.2 | 46 | 22 | 10.1 | 36 | 11 | 4.0 | 14 | 14 | 2.0 |
| Other grasses | 5 | 42 | 2.1 | 14 | 30 | 4.2 | 15 | 15 | 2.3 | 14 | 24 | 3.4 | 24 | 33 | 8.0 | 20 | 13 | 2.6 |
| Total | | | 68.0 | | | 66.3 | | | 96.6 | | | 88.9 | | | 91.0 | | | 64.8 |

Consumption of Macartney rose was calculated from botanical composition of diet data.

Appendix Table C.30 Calculation of forage disappearance, animal unit basis, by cattle on a seacoast bluestem-Macartney rose pasture in Calhoun County, Texas. Data taken from Durham and Kothmann (1977).

Total forage utilization over 110 days (22 Dec-10 Apr) = 475.6 g/m$^2$ (Appendix Table C.29) = 4.32 g/m$^2$ per day.
Total area grazed = 7.2 ha = 72,000 m$^2$ = 17.8 acres.
Area was grazed by four cows. Assume cows were 1000 lbs = 4 AU.
Average daily consumption = (72,000 m$^2$)(4.32 g/m$^2$/d)/4 AU = 77,760 g/AUD = 171.28 lbs/AUD

Total forage production = forage utilized + forage remaining = (475.6 – 20.8) + 291 = 746 g/m$^2$
Utilization rate = 455/746 = 0.610

## ADDITIONAL PLANT AND VEGETATION DATA

**Bovey, R.W., R.E. Meyer, and H.L. Morton. 1972. Herbage production following brush control with herbicides in Texas. Journal of Range Management 25:136-142.**

Victoria County, Katy gravelly sandy loam.
Live oak-little bluestem community (shrub live oak = 2 m tall): live oak, little bluestem, brownseed paspalum, indiangrass, threeawns, lovegrasses, knotroot bristlegrass, bitter sneezeweed, Lindheimer doveweed.
Oct 1967 herbaceous biomass = 185 g/m$^2$ grasses + 18 g/m$^2$ forbs
Area bulldozed in Jul 1963 and harvested in Apr 1970 = 114 g/m$^2$ live oak regrowth + 2 g/m$^2$ grasses + 2 g/m$^2$ forbs
Victoria 1967 PPT = 33.90 inches = 86.1 cm    Oct 1966-Sep 1967 = 28.18 inches = 71.6 cm

PUE = 203 g/m$^2$/71.6 cm = 2.84 g/m$^2$/cm + live oak production

**Box, Thadis W. and Richard S. White. 1969. Fall and winter burning of South Texas brush ranges. Journal of Range Management 22:373-376.**

Chaparral community, Welder Wildlife Refuge. Mesquite-huisache-blackbrush community

Sampled Aug 1967
Herbaceous production (24% buffalograss, 9% silver bluestem, 8% ruellia, 15% Texas broomweed):
163.6 g/m$^2$ = 97.7 g/m$^2$ grasses + 65.9 g/m$^2$ forbs

**Buckley, P.E. and J.D. Dodd. 1969. Heavy precipitation influences saline clay flat vegetation. Journal of Range Management 22:405-407.**

18 mi NNE of Zapata. Prickly pear-saladillo-mesquite community. Root plowed in 1962.
Sampled in Nov 1967 following Hurricane Beulah.
Herbaceous production (56% Hall panicum, 20% curly mesquite, 10% whorled dropseed): 136 g/m$^2$
1967 PPT at study site = 26.39 inches = 67.0 cm

PUE = 136 g/m$^2$/67.0 cm = 2.03 g/m$^2$/cm + shrub production

**Dodd, J.D. and S.T. Holtz. 1972. Integration of burning with mechanical manipulation of South Texas grassland. Journal of Range Management 25:130-136.**

Cartwright Ranch, Goliad County. Blackbrush-Texas persimmon-hogplum community.
Sampled Jun 1968.
Herbaceous production = 145 g/m$^2$ = 41 g/m$^2$ grass (24% sedge, 20% Texas grama, 16% threeawns) + 104 g/m$^2$ forbs (8% orange zexmenia, 4% Texas broomweed)
Jun 1967-May 1968 PPT at Goliad = 54.45 inches = 138.3 cm

PUE = 145 g/m$^2$/138.3 cm = 1.05 g/m$^2$/cm + shrub production

**Drawe, D. Lynn and Thadis W. Box. 1969. High rates of nitrogen fertilization influence coastal prairie range. Journal of Range Management 22:32-36.**

Bunchgrass-annual forb community on Zavala fine sandy loam, Welder Wildlife Refuge.
21% camphorweed, 14% knotgrass, 12% balsamscale, 10% sandbur, 9% signalgrass, 6% seacoast
Sampled in August of each year.

| | 1965 | 1966 | 1967 | |
|---|---|---|---|---|
| Herbaceous production ($g/m^2$): | 237 | 228 | 252 | |
| Grasses ($g/m^2$): | 159 | 137 | 192 | |
| Forbs ($g/m^2$): | 78 | 91 | 60 | |
| Sep-Aug PPT (cm): | 68.5 | 101.3 | 65.2 | Refugio PPT(0.904) |
| PUE ($g/m^2/cm$): | 3.46 | 2.25 | 3.87 | Mean = 3.20 |

Jan 1964-Sep 1965 PPT Refugio = 50.59 inches
Jan 1964-Sep 1965 PPT WWR = 45.74 inches 45.74/50.59 = 0.904

**Powell, Jeff and Thadis W. Box. 1967. Mechanical control and fertilization as brush management practices affect forage production in South Texas. Journal of Range Management 20:227-236.**

Chaparral-bristlegrass community, Victoria clay, Welder Wildlife Refuge.
Blackbrush-huisache-mesquite (49% brush cover).
Herbaceous: plains bristlegrass (15%), buffalograss (11%), ragweed, Texas broomweed (31% forbs)
Forage production: 101 $g/m^2$ in 1964; 162 $g/m^2$ in 1965

Oct 1963-Sep 1964 PPT = 0.904(Refugio) = 0.904(33.37) = 30.17 inches = 76.6 cm
Oct 1964-Sep 1965 PPT = 0.904(Refugio Oct-Dec) + 17.44 inches = 0.904(7.03) + 17.44 = 60.5 cm

1964 PUE = 101 $g/m^2$/76.6 cm = 1.32 $g/m^2/cm$ 1965 PUE = 162 $g/m^2$/60.5 cm = 2.68 $g/m^2/cm$

# APPENDIX D ANIMALS

Appendix Table D.1 Estimation of cattle stocking rates (moderate level) for vegetation plot types in the Victoria County EDYS model. Values assume fair range condition and no woody plant cover.

| Range Type | Annual Forage ($g/m^2$) | Available Forage ($g/m^2$) | AU Forage Requirement (g/AUD)(365 d) | Stocking Rate ($m^2$/AU) | Stocking Rate (ac/AU) |
|---|---|---|---|---|---|
| Blackland | 555 | 277 | 5,634,870 | 20,342 | 5.03 |
| Clayey Bottomland | 358 | 179 | 5,634,870 | 31,480 | 7.79 |
| Clay Loam | 308 | 154 | 5,634,870 | 36,590 | 9.06 |
| Claypan Prairie | 345 | 172 | 5,634,870 | 32,761 | 8.08 |
| Deep Sand | 228 | 114 | 5,634,870 | 49,429 | 12.23 |
| Gravelly | 224 | 112 | 5,634,870 | 50,311 | 12.45 |
| Gray Sandy Loam | 188 | 94 | 5,634,870 | 59,945 | 14.84 |
| Loamy Bottomland | 447 | 223 | 5,634,870 | 25,268 | 6.24 |
| Loamy Prairie | 592 | 296 | 5,634,870 | 19,037 | 4.71 |
| Loamy Sand | 133 | 66 | 5,634,870 | 85,377 | 20.96 |
| Rolling Blackland | 275 | 137 | 5,634,870 | 41,130 | 10.14 |
| Salt Marsh | 706 | 353 | 5,634,870 | 15,963 | 3.95 |
| Salty Bottomland | 350 | 175 | 5,634,870 | 31,638 | 7.97 |
| Sandy Bottomland | 194 | 97 | 5,634,870 | 58,091 | 14.38 |
| Sandy Loam | 384 | 192 | 5,634,870 | 29,348 | 7.26 |
| Sandy Prairie | 596 | 298 | 5,634,870 | 18,909 | 4.68 |
| Shallow | 141 | 70 | 5,634,870 | 80,498 | 19.79 |
| Tight Sandy Loam | 412 | 206 | 5,634,870 | 27,354 | 6.77 |
| Improved Pasture | 566 | 283 | 5,634,870 | 19,911 | 4.91 |
| Mean | | | | | 9.54 |

Annual forage = fair range condition (Appendix Table C.2).
Available forage = (Annual Forage)(0.5), where 0.5 is proper management harvest rate.
AU Forage Requirement = 15,438 g/AUD = (Table 7.1). Stocking Rate = (AU Forage Requirement)/(Available Forage).

Appendix Table D.2 Estimation of cattle stocking rates (moderate level) for vegetation plot types, adjusted for woody plant cover, in the Victoria County EDYS model. Values assume fair range condition.

| Range Type | Woody Cover (%) | Annual Forage ($g/m^2$) | Available Forage ($g/m^2$) | Forage Requirement (g/AU) | Stocking Rate ($m^2$/AU) | Stocking Rate (ac/AU) |
|---|---|---|---|---|---|---|
| Blackland | 0 | 555 | 277 | 5,634,870 | 20,342 | 5.03 |
| Blackland | 1 | 552 | 276 | 5,634,870 | 20,416 | 5.04 |
| Blackland | 5 | 534 | 267 | 5,634,870 | 21,104 | 5.17 |
| Blackland | 18 | 475 | 237 | 5,634,870 | 23,776 | 5.85 |
| Blackland | 38 | 388 | 194 | 5,634,870 | 29,046 | 7.16 |
| Blackland | 63 | 276 | 138 | 5,634,870 | 40,832 | 10.09 |
| Blackland | 83 | 186 | 93 | 5,634,870 | 60,590 | 14.97 |
| Blackland | 95 | 133 | 67 | 5,634,870 | 84,103 | 20.78 |
| Clayey Bottomland | 0 | 358 | 179 | 5,634,870 | 31,480 | 7.79 |
| Clayey Bottomland | 1 | 354 | 177 | 5,634,870 | 31,835 | 7.87 |
| Clayey Bottomland | 5 | 342 | 171 | 5,634,870 | 32,952 | 8.14 |
| Clayey Bottomland | 18 | 307 | 153 | 5,634,870 | 36,829 | 9.10 |
| Clayey Bottomland | 38 | 249 | 124 | 5,634,870 | 45,443 | 11.23 |
| Clayey Bottomland | 63 | 178 | 89 | 5,634,870 | 63,313 | 15.64 |
| Clayey Bottomland | 83 | 120 | 60 | 5,634,870 | 93,914 | 23.21 |
| Clayey Bottomland | 95 | 86 | 43 | 5,634,870 | 131,043 | 32.38 |
| Clay Loam | 0 | 308 | 154 | 5,634,870 | 36,590 | 9.06 |
| Clay Loam | 5 | 298 | 149 | 5,634,870 | 37,818 | 9.34 |
| Clay Loam | 18 | 266 | 133 | 5,634,870 | 42,367 | 10.47 |
| Clay Loam | 38 | 214 | 107 | 5,634,870 | 52,662 | 13.01 |
| Clay Loam | 63 | 155 | 77 | 5,634,870 | 73,180 | 18.08 |
| Clay Loam | 83 | 101 | 50 | 5,634,870 | 112,698 | 27.85 |
| Clay Loam | 95 | 74 | 37 | 5,634,870 | 152,564 | 37.70 |
| Claypan Prairie | 0 | 345 | 172 | 5,634,870 | 32,761 | 8.08 |
| Claypan Prairie | 1 | 344 | 172 | 5,634,870 | 32,761 | 8.08 |
| Claypan Prairie | 5 | 331 | 165 | 5,634,870 | 34,151 | 8.44 |
| Claypan Prairie | 18 | 297 | 148 | 5,634,870 | 38,074 | 9.40 |
| Claypan Prairie | 38 | 239 | 119 | 5,634,870 | 47,352 | 11.70 |
| Claypan Prairie | 63 | 171 | 85 | 5,634,870 | 66,292 | 16.38 |
| Claypan Prairie | 83 | 114 | 57 | 5,634,870 | 98,857 | 24.43 |
| Claypan Prairie | 95 | 83 | 41 | 5,634,870 | 137,436 | 33.96 |
| Deep Sand | 0 | 228 | 114 | 5,634,870 | 49,429 | 12.23 |
| Deep Sand | 5 | 219 | 109 | 5,634,870 | 51,697 | 12.77 |
| Deep Sand | 18 | 196 | 98 | 5,634,870 | 57,499 | 13.47 |
| Deep Sand | 38 | 158 | 79 | 5,634,870 | 71,327 | 17.62 |
| Deep Sand | 63 | 113 | 57 | 5,634,870 | 98,857 | 24.43 |
| Deep Sand | 83 | 77 | 38 | 5,634,870 | 148,286 | 36.64 |
| Deep Sand | 95 | 54 | 27 | 5,634,870 | 208,699 | 51.57 |
| Gravelly | 0 | 224 | 112 | 5,634,870 | 50,311 | 12.45 |
| Gravelly | 5 | 216 | 108 | 5,634,870 | 52,175 | 12.89 |
| Gravelly | 18 | 194 | 97 | 5,634,870 | 58,091 | 14.35 |
| Gravelly | 38 | 156 | 78 | 5,634,870 | 72,242 | 17.85 |
| Gravelly | 63 | 111 | 56 | 5,634,870 | 100,623 | 24.86 |
| Gravelly | 83 | 76 | 38 | 5,634,870 | 148,286 | 36.64 |
| Gravelly | 95 | 54 | 27 | 5,634,870 | 208,699 | 51.57 |
| Gray Sandy Loam | 0 | 188 | 94 | 5,634,870 | 59,945 | 14.84 |
| Gray Sandy Loam | 5 | 181 | 91 | 5,634,870 | 61,922 | 15.30 |
| Gray Sandy Loam | 18 | 168 | 84 | 5,634,870 | 67,082 | 16.58 |
| Gray Sandy Loam | 38 | 131 | 66 | 5,634,870 | 85,377 | 21.10 |
| Gray Sandy Loam | 63 | 99 | 50 | 5,634,870 | 112,698 | 27.85 |
| Gray Sandy Loam | 83 | 65 | 33 | 5,634,870 | 170,754 | 42.19 |
| Gray Sandy Loam | 95 | 44 | 22 | 5,634,870 | 256,130 | 63.29 |
| Loamy Bottomland | 0 | 447 | 224 | 5,634,870 | 25,155 | 6.22 |
| Loamy Bottomland | 1 | 443 | 222 | 5,634,870 | 25,382 | 6.27 |
| Loamy Bottomland | 5 | 425 | 213 | 5,634,870 | 26,455 | 6.54 |
| Loamy Bottomland | 18 | 399 | 200 | 5,634,870 | 28,174 | 6.96 |
| Loamy Bottomland | 38 | 309 | 155 | 5,634,870 | 36,354 | 8.98 |
| Loamy Bottomland | 63 | 232 | 116 | 5,634,870 | 48,576 | 12.00 |
| Loamy Bottomland | 83 | 149 | 75 | 5,634,870 | 75,133 | 18.57 |
| Loamy Bottomland | 95 | 106 | 53 | 5,634,870 | 106,318 | 26.27 |
| Loamy Prairie | 0 | 592 | 296 | 5,634,870 | 19,037 | 4.71 |
| Loamy Prairie | 1 | 587 | 294 | 5,634,870 | 19,166 | 4.74 |
| Loamy Prairie | 5 | 570 | 285 | 5,634,870 | 19,771 | 4.89 |
| Loamy Prairie | 18 | 506 | 253 | 5,634,870 | 22,271 | 5.50 |

Appendix Table D.2 (Cont.)

| Range Type | Woody Cover (%) | Annual Forage (g/m²) | Available Forage (g/m²) | Forage Requirement (g/AU) | Stocking Rate (m²/AU) | Stocking Rate (ac/AU) |
|---|---|---|---|---|---|---|
| Loamy Prairie | 38 | 405 | 203 | 5,634,870 | 27,758 | 686 |
| Loamy Prairie | 63 | 295 | 148 | 5,634,870 | 38,074 | 9.41 |
| Loamy Prairie | 83 | 198 | 99 | 5,634,870 | 56,938 | 14.07 |
| Loamy Prairie | 95 | 143 | 72 | 5,634,870 | 78,262 | 19.34 |
| Loamy Sand | 0 | 133 | 66 | 5,634,870 | 85,377 | 20.96 |
| Loamy Sand | 5 | 128 | 64 | 5,634,870 | 88,045 | 21.76 |
| Loamy Sand | 18 | 114 | 57 | 5,634,870 | 98,857 | 24.43 |
| Loamy Sand | 38 | 93 | 47 | 5,634,870 | 119,891 | 29.62 |
| Loamy Sand | 63 | 88 | 44 | 5,634,870 | 128,065 | 31.64 |
| Loamy Sand | 83 | 43 | 22 | 5,634,870 | 256,130 | 63.29 |
| Rolling Blackland | 0 | 275 | 137 | 5,634,870 | 41,130 | 10.14 |
| Rolling Blackland | 5 | 268 | 134 | 5,634,870 | 42,051 | 10.39 |
| Rolling Blackland | 18 | 235 | 118 | 5,634,870 | 47,753 | 11.80 |
| Rolling Blackland | 38 | 192 | 96 | 5,634,870 | 58,696 | 14.50 |
| Rolling Blackland | 63 | 135 | 68 | 5,634,870 | 85,836 | 21.21 |
| Rolling Blackland | 83 | 92 | 46 | 5,634,870 | 122,497 | 30.27 |
| Rolling Blackland | 95 | 65 | 33 | 5,634,870 | 170,754 | 42.19 |
| Salt Marsh | 0 | 706 | 353 | 5,634,870 | 15,963 | 3.95 |
| Salt Marsh | 5 | 628 | 314 | 5,634,870 | 17,945 | 4.43 |
| Salt Marsh | 18 | 558 | 279 | 5,634,870 | 20,269 | 5.01 |
| Salt Marsh | 63 | 324 | 162 | 5,634,870 | 34,783 | 8.59 |
| Salt Marsh | 83 | 219 | 110 | 5,634,870 | 51,226 | 12.66 |
| Salty Bottomland | 0 | 350 | 175 | 5,634,870 | 31,638 | 7.97 |
| Salty Bottomland | 5 | 313 | 157 | 5,634,870 | 35,891 | 8.87 |
| Salty Bottomland | 18 | 279 | 140 | 5,634,870 | 40,249 | 9.95 |
| Salty Bottomland | 38 | 227 | 114 | 5,634,870 | 49,429 | 12.21 |
| Salty Bottomland | 63 | 162 | 81 | 5,634,870 | 69,566 | 17.19 |
| Salty Bottomland | 83 | 110 | 55 | 5,634,870 | 102,552 | 25.34 |
| Salty Bottomland | 95 | 78 | 39 | 5,634,870 | 147,048 | 36.33 |
| Sandy Bottomland | 0 | 194 | 97 | 5,634,870 | 58,091 | 14.38 |
| Sandy Bottomland | 5 | 188 | 94 | 5,634,870 | 59,945 | 14.81 |
| Sandy Bottomland | 18 | 164 | 82 | 5,634,870 | 68,718 | 16.98 |
| Sandy Bottomland | 38 | 132 | 66 | 5,634,870 | 85,377 | 20.96 |
| Sandy Bottomland | 63 | 107 | 54 | 5,634,870 | 104,349 | 25.78 |
| Sandy Bottomland | 83 | 66 | 33 | 5,634,870 | 170,754 | 42.19 |
| Sandy Bottomland | 95 | 47 | 24 | 5,634,870 | 234,786 | 58.01 |
| Sandy Loam | 0 | 384 | 192 | 5,634,870 | 29,348 | 7.26 |
| Sandy Loam | 1 | 383 | 192 | 5,634,870 | 29,348 | 7.26 |
| Sandy Loam | 5 | 372 | 186 | 5,634,870 | 30,295 | 7.49 |
| Sandy Loam | 18 | 329 | 165 | 5,634,870 | 34,151 | 8.44 |
| Sandy Loam | 38 | 269 | 135 | 5,634,870 | 41,740 | 10.31 |
| Sandy Loam | 63 | 192 | 96 | 5,634,870 | 58,696 | 14.50 |
| Sandy Loam | 83 | 129 | 65 | 5,634,870 | 86,690 | 21.42 |
| Sandy Loam | 95 | 97 | 49 | 5,634,870 | 114,997 | 28.42 |
| Sandy Prairie | 0 | 596 | 298 | 5,634,870 | 18,909 | 4.68 |
| Sandy Prairie | 5 | 575 | 288 | 5,634,870 | 19,564 | 4.83 |
| Sandy Prairie | 18 | 510 | 255 | 5,634,870 | 22,098 | 5.46 |
| Sandy Prairie | 38 | 416 | 208 | 5,634,870 | 27,091 | 6.69 |
| Sandy Prairie | 63 | 297 | 149 | 5,634,870 | 37,811 | 9.34 |
| Sandy Prairie | 83 | 200 | 100 | 5,634,870 | 56,349 | 13.92 |
| Sandy Prairie | 95 | 143 | 72 | 5,634,870 | 78,262 | 19.34 |
| Shallow | 0 | 141 | 70 | 5,634,870 | 80,498 | 19.79 |
| Shallow | 5 | 136 | 68 | 5,634,870 | 85,836 | 21.21 |
| Shallow | 18 | 121 | 61 | 5,634,870 | 92,375 | 22.83 |
| Shallow | 38 | 99 | 50 | 5,634,870 | 112,698 | 27.84 |
| Shallow | 63 | 70 | 35 | 5,634,870 | 160,996 | 39.78 |
| Shallow | 83 | 46 | 23 | 5,634,870 | 244,994 | 60.54 |
| Shallow | 95 | 37 | 19 | 5,634,870 | 296,572 | 73.28 |
| Tight Sandy Loam | 0 | 412 | 206 | 5,634,870 | 27,354 | 6.77 |
| Tight Sandy Loam | 5 | 397 | 199 | 5,634,870 | 28,316 | 7.00 |
| Tight Sandy Loam | 18 | 356 | 178 | 5,634,870 | 31,657 | 7.82 |
| Tight Sandy Loam | 38 | 288 | 144 | 5,634,870 | 39,131 | 9.67 |
| Tight Sandy Loam | 63 | 204 | 102 | 5,634,870 | 55,244 | 13.65 |
| Tight Sandy Loam | 83 | 138 | 69 | 5,634,870 | 81,665 | 20.18 |
| Tight Sandy Loam | 95 | 99 | 50 | 5,634,870 | 112,698 | 27.84 |

Appendix Table D.2 (Cont.)

| Range Type | Woody Cover (%) | Annual Forage ($g/m^2$) | Available Forage ($g/m^2$) | Forage Requirement (g/AU) | Stocking Rate ($m^2$/AU) | Stocking Rate (ac/AU) |
|---|---|---|---|---|---|---|
| Improved Pasture | 0 | 566 | 283 | 5,634,870 | 19,911 | 4.92 |
| Improved Pasture | 5 | 543 | 271 | 5,634,870 | 20,793 | 5.14 |
| Improved Pasture | 18 | 484 | 242 | 5,634,870 | 23,285 | 5.75 |
| Caliche Pit | 0 | 100 | 50 | 5,634,870 | 112,698 | 27.84 |
| Caliche Pit | 5 | 97 | 49 | 5,634,870 | 114,997 | 28.42 |
| Caliche Pit | 18 | 87 | 44 | 5,634,870 | 128,065 | 31.64 |
| Caliche Pit | 38 | 70 | 35 | 5,634,870 | 160,996 | 39.77 |
| Disturbed Site | 0 | 100 | 50 | 5,634,870 | 112,698 | 27.84 |
| Disturbed Site | 1 | 100 | 50 | 5,634,870 | 112,698 | 27.84 |
| Disturbed Site | 5 | 97 | 49 | 5,634,870 | 114,997 | 28.42 |
| Disturbed Site | 18 | 86 | 43 | 5,634,870 | 131,043 | 32.37 |
| Disturbed Site | 38 | 69 | 35 | 5,634,870 | 160,996 | 39.37 |
| Disturbed Site | 63 | 49 | 25 | 5,634,870 | 225,396 | 55.68 |
| Disturbed Site | 83 | 33 | 17 | 5,634,870 | 331,463 | 81.90 |

Annual forage = fair range condition (Appendix Table C.2).
Available forage = (Annual Forage)(0.5), where 0.5 is proper management harvest rate.
AU Forage Requirement = 15,438 g/AUD (Table 6.1).
Stocking rate = (AU Forage Requirement)(Available Forage)[1.00 – 0.8(percent woody plant cover/100)]; Appendix Table C.24.

# APPENDIX E PLANT PARAMETERS

Appendix Table E.1 General species characteristics for species used in the Victoria County EDYS model.

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.34 | 0.12 | 0.38 | 0.11 | 0.05 | 0.00 |
| Pecan | 0.32 | 0.11 | 0.40 | 0.12 | 0.05 | 0.00 |
| Hackberry | 0.16 | 0.06 | 0.55 | 0.17 | 0.06 | 0.00 |
| Mesquite | 0.14 | 0.10 | 0.39 | 0.28 | 0.09 | 0.00 |
| Post oak | 0.20 | 0.07 | 0.51 | 0.16 | 0.06 | 0.00 |
| Live oak | 0.24 | 0.08 | 0.48 | 0.15 | 0.05 | 0.00 |
| Blackbrush | 0.27 | 0.12 | 0.34 | 0.18 | 0.09 | 0.00 |
| Baccharis | 0.26 | 0.12 | 0.34 | 0.19 | 0.09 | 0.00 |
| Sea oxeye | 0.32 | 0.15 | 0.28 | 0.19 | 0.06 | 0.00 |
| Granjeno | 0.28 | 0.12 | 0.33 | 0.18 | 0.09 | 0.00 |
| McCartney rose | 0.32 | 0.15 | 0.28 | 0.19 | 0.06 | 0.00 |
| Rattlepod | 0.27 | 0.11 | 0.34 | 0.19 | 0.09 | 0.00 |
| Greenbriar | 0.25 | 0.25 | 0.15 | 0.18 | 0.16 | 0.00 |
| Mustang grape | 0.23 | 0.10 | 0.35 | 0.17 | 0.15 | 0.00 |
| Prickly pear | 0.16 | 0.08 | 0.37 | 0.38 | 0.01 | 0.00 |
| Big bluestem | 0.24 | 0.24 | 0.10 | 0.21 | 0.21 | 0.00 |
| Bushy bluestem | 0.23 | 0.36 | 0.13 | 0.16 | 0.12 | 0.00 |
| Purple threeawn | 0.33 | 0.32 | 0.07 | 0.14 | 0.14 | 0.00 |
| Arrowfeather threeawn | 0.23 | 0.36 | 0.13 | 0.16 | 0.12 | 0.00 |
| Silver bluestem | 0.25 | 0.25 | 0.10 | 0.20 | 0.20 | 0.00 |
| Sideoats grama | 0.31 | 0.31 | 0.08 | 0.15 | 0.15 | 0.00 |
| Buffalograss | 0.28 | 0.27 | 0.12 | 0.05 | 0.28 | 0.00 |
| Sandbur | 0.26 | 0.39 | 0.12 | 0.08 | 0.15 | 0.00 |
| Hooded windmillgrass | 0.23 | 0.24 | 0.14 | 0.05 | 0.34 | 0.00 |
| Bermudagrass | 0.28 | 0.27 | 0.15 | 0.05 | 0.25 | 0.00 |
| Saltgrass | 0.23 | 0.36 | 0.13 | 0.16 | 0.12 | 0.00 |
| Virginia wildrye | 0.23 | 0.23 | 0.11 | 0.22 | 0.21 | 0.00 |
| Pan-American balsamscale | 0.23 | 0.36 | 0.13 | 0.16 | 0.12 | 0.00 |
| Plains lovegrass | 0.18 | 0.18 | 0.13 | 0.26 | 0.25 | 0.00 |
| Switchgrass | 0.25 | 0.25 | 0.10 | 0.20 | 0.20 | 0.00 |
| Longtom | 0.36 | 0.35 | 0.08 | 0.03 | 0.18 | 0.00 |
| Brownseed paspalum | 0.22 | 0.33 | 0.10 | 0.16 | 0.19 | 0.00 |
| Thin paspalum | 0.22 | 0.21 | 0.17 | 0.06 | 0.34 | 0.00 |
| Common reed | 0.18 | 0.18 | 0.18 | 0.26 | 0.20 | 0.00 |

Appendix Table E.1 (Cont.)

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.31 | 0.31 | 0.08 | 0.15 | 0.15 | 0.00 |
| Knotroot bristelgrass | 0.26 | 0.26 | 0.14 | 0.05 | 0.29 | 0.00 |
| Plains bristlegrass | 0.31 | 0.46 | 0.03 | 0.12 | 0.08 | 0.00 |
| Indiangrass | 0.37 | 0.36 | 0.05 | 0.11 | 0.11 | 0.00 |
| Milo | 0.25 | 0.25 | 0.10 | 0.20 | 0.20 | 0.00 |
| Johnsongrass | 0.35 | 0.34 | 0.06 | 0.13 | 0.12 | 0.00 |
| Gulf cordgrass | 0.31 | 0.46 | 0.03 | 0.12 | 0.08 | 0.00 |
| Tall dropseed | 0.26 | 0.26 | 0.10 | 0.19 | 0.19 | 0.00 |
| Smutgrass | 0.31 | 0.46 | 0.03 | 0.12 | 0.08 | 0.00 |
| Texas wintergrass | 0.28 | 0.28 | 0.13 | 0.04 | 0.27 | 0.00 |
| Littletooth sedge | 0.28 | 0.27 | 0.13 | 0.05 | 0.27 | 0.00 |
| Flatsedge | 0.39 | 0.38 | 0.05 | 0.09 | 0.09 | 0.00 |
| Olney bulrush | 0.26 | 0.38 | 0.05 | 0.20 | 0.11 | 0.00 |
| Cattail | 0.39 | 0.38 | 0.05 | 0.09 | 0.09 | 0.00 |
| Spiny aster | 0.49 | 0.20 | 0.05 | 0.17 | 0.09 | 0.00 |
| Ragweed | 0.28 | 0.28 | 0.09 | 0.18 | 0.17 | 0.00 |
| Wild indigo | 0.24 | 0.25 | 0.09 | 0.15 | 0.27 | 0.00 |
| Old-mans beard | 0.29 | 0.28 | 0.08 | 0.09 | 0.26 | 0.00 |
| Bundleflower | 0.29 | 0.30 | 0.08 | 0.16 | 0.17 | 0.00 |
| Mistflower | 0.28 | 0.28 | 0.09 | 0.18 | 0.17 | 0.00 |
| Camphorweed | 0.49 | 0.20 | 0.05 | 0.17 | 0.09 | 0.00 |
| Frogfruit | 0.16 | 0.17 | 0.20 | 0.07 | 0.40 | 0.00 |
| Snoutbean | 0.21 | 0.20 | 0.17 | 0.06 | 0.36 | 0.00 |
| Ruellia | 0.19 | 0.19 | 0.19 | 0.06 | 0.37 | 0.00 |
| Glasswort | 0.14 | 0.10 | 0.25 | 0.25 | 0.26 | 0.00 |
| Bush sunflower | 0.28 | 0.28 | 0.09 | 0.18 | 0.17 | 0.00 |
| Orange zexmenia | 0.28 | 0.28 | 0.09 | 0.18 | 0.17 | 0.00 |
| Giant ragweed | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Partridge pea | 0.19 | 0.19 | 0.19 | 0.06 | 0.37 | 0.00 |
| Woolly doveweed | 0.14 | 0.15 | 0.14 | 0.29 | 0.28 | 0.00 |
| Broomweed | 0.19 | 0.19 | 0.12 | 0.25 | 0.25 | 0.00 |
| Sunflower | 0.08 | 0.07 | 0.17 | 0.34 | 0.34 | 0.00 |
| Sumpweed | 0.49 | 0.20 | 0.05 | 0.17 | 0.09 | 0.00 |

Appendix Table E.2 Tissue allocation in mature plants, by plant part (proportion of total), and root:shoot ratio (R:S) for species included in the Victoria County EDYS model.

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.08 | 0.20 | 0.10 | 0.22 | 0.40 | 0.00 |
| Pecan | 0.11 | 0.32 | 0.15 | 0.08 | 0.34 | 0.00 |
| Hackberry | 0.06 | 0.16 | 0.27 | 0.08 | 0.43 | 0.00 |
| Mesquite | 0.08 | 0.23 | 0.12 | 0.22 | 0.31 | 0.00 |
| Post oak | 0.07 | 0.20 | 0.25 | 0.08 | 0.40 | 0.00 |
| Live oak | 0.10 | 0.20 | 0.15 | 0.07 | 0.48 | 0.00 |
| Blackbrush | 0.05 | 0.20 | 0.05 | 0.20 | 0.50 | 0.00 |
| Baccharis | 0.05 | 0.20 | 0.05 | 0.20 | 0.50 | 0.00 |
| Sea oxeye | 0.14 | 0.40 | 0.10 | 0.15 | 0.21 | 0.00 |
| Granjeno | 0.04 | 0.18 | 0.04 | 0.22 | 0.52 | 0.00 |
| McCartney rose | 0.14 | 0.40 | 0.03 | 0.18 | 0.25 | 0.00 |
| Rattlepod | 0.05 | 0.20 | 0.10 | 0.15 | 0.50 | 0.00 |
| Greenbriar | 0.15 | 0.15 | 0.15 | 0.30 | 0.25 | 0.00 |
| Mustang grape | 0.03 | 0.20 | 0.10 | 0.15 | 0.52 | 0.00 |
| Prickly pear | 0.10 | 0.22 | 0.20 | 0.46 | 0.02 | 0.00 |
| Big bluestem | 0.10 | 0.24 | 0.11 | 0.25 | 0.30 | 0.00 |
| Bushy bluestem | 0.07 | 0.25 | 0.10 | 0.25 | 0.33 | 0.00 |
| Purple threeawn | 0.12 | 0.25 | 0.08 | 0.10 | 0.45 | 0.00 |
| Arrowfeather threeawn | 0.10 | 0.15 | 0.10 | 0.25 | 0.40 | 0.00 |
| Silver bluestem | 0.12 | 0.24 | 0.09 | 0.25 | 0.30 | 0.00 |
| Sideoats grama | 0.12 | 0.24 | 0.08 | 0.26 | 0.30 | 0.00 |
| Buffalograss | 0.16 | 0.27 | 0.10 | 0.12 | 0.35 | 0.00 |
| Sandbur | 0.02 | 0.40 | 0.10 | 0.15 | 0.33 | 0.00 |
| Hooded windmillgrass | 0.12 | 0.24 | 0.07 | 0.05 | 0.52 | 0.00 |
| Bermudagrass | 0.12 | 0.25 | 0.10 | 0.05 | 0.48 | 0.00 |
| Saltgrass | 0.09 | 0.36 | 0.19 | 0.24 | 0.12 | 0.00 |
| Virginia wildrye | 0.12 | 0.23 | 0.05 | 0.30 | 0.30 | 0.00 |
| Pan-American balsamscale | 0.10 | 0.15 | 0.10 | 0.25 | 0.40 | 0.00 |
| Plains lovegrass | 0.12 | 0.24 | 0.08 | 0.25 | 0.31 | 0.00 |
| Switchgrass | 0.11 | 0.24 | 0.10 | 0.25 | 0.30 | 0.00 |
| Longtom | 0.13 | 0.25 | 0.08 | 0.22 | 0.32 | 0.00 |
| Brownseed paspalum | 0.10 | 0.22 | 0.06 | 0.30 | 0.32 | 0.00 |
| Thin paspalum | 0.11 | 0.21 | 0.09 | 0.20 | 0.39 | 0.00 |
| Common reed | 0.15 | 0.25 | 0.10 | 0.20 | 0.30 | 0.00 |

Appendix Table E.2 (Cont.)

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.13 | 0.25 | 0.06 | 0.26 | 0.30 | 0.00 |
| Knotroot bristelgrass | 0.14 | 0.25 | 0.10 | 0.26 | 0.25 | 0.00 |
| Plains bristlegrass | 0.04 | 0.17 | 0.11 | 0.45 | 0.23 | 0.00 |
| Indiangrass | 0.10 | 0.24 | 0.06 | 0.30 | 0.30 | 0.00 |
| Milo | 0.10 | 0.20 | 0.05 | 0.25 | 0.40 | 0.00 |
| Johnsongrass | 0.12 | 0.23 | 0.05 | 0.30 | 0.30 | 0.00 |
| Gulf cordgrass | 0.04 | 0.17 | 0.11 | 0.45 | 0.23 | 0.00 |
| Tall dropseed | 0.11 | 0.24 | 0.05 | 0.30 | 0.30 | 0.00 |
| Smutgrass | 0.04 | 0.17 | 0.11 | 0.45 | 0.23 | 0.00 |
| Texas wintergrass | 0.10 | 0.20 | 0.05 | 0.40 | 0.25 | 0.00 |
| Littletooth sedge | 0.14 | 0.27 | 0.07 | 0.10 | 0.42 | 0.00 |
| Flatsedge | 0.18 | 0.35 | 0.06 | 0.12 | 0.29 | 0.00 |
| Olney bulrush | 0.04 | 0.14 | 0.11 | 0.47 | 0.24 | 0.00 |
| Cattail | 0.20 | 0.20 | 0.04 | 0.28 | 0.28 | 0.00 |
| Spiny aster | 0.28 | 0.12 | 0.20 | 0.20 | 0.20 | 0.00 |
| Ragweed | 0.15 | 0.20 | 0.10 | 0.30 | 0.25 | 0.00 |
| Wild indigo | 0.04 | 0.18 | 0.26 | 0.26 | 0.26 | 0.00 |
| Old-mans beard | 0.15 | 0.28 | 0.10 | 0.24 | 0.23 | 0.00 |
| Bundleflower | 0.08 | 0.18 | 0.10 | 0.32 | 0.32 | 0.00 |
| Mistflower | 0.12 | 0.25 | 0.12 | 0.26 | 0.25 | 0.00 |
| Camphorweed | 0.28 | 0.12 | 0.10 | 0.32 | 0.18 | 0.00 |
| Frogfruit | 0.08 | 0.17 | 0.10 | 0.30 | 0.35 | 0.00 |
| Snoutbean | 0.10 | 0.20 | 0.10 | 0.30 | 0.30 | 0.00 |
| Ruellia | 0.15 | 0.25 | 0.15 | 0.05 | 0.40 | 0.00 |
| Glasswort | 0.15 | 0.15 | 0.24 | 0.10 | 0.36 | 0.00 |
| Bush sunflower | 0.12 | 0.25 | 0.12 | 0.26 | 0.25 | 0.00 |
| Orange zexmenia | 0.13 | 0.25 | 0.12 | 0.25 | 0.25 | 0.00 |
| Giant ragweed | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Partridge pea | 0.19 | 0.19 | 0.19 | 0.06 | 0.37 | 0.00 |
| Woolly doveweed | 0.14 | 0.15 | 0.14 | 0.29 | 0.28 | 0.00 |
| Broomweed | 0.19 | 0.19 | 0.12 | 0.25 | 0.25 | 0.00 |
| Sunflower | 0.12 | 0.20 | 0.10 | 0.30 | 0.23 | 0.05 |
| Sumpweed | 0.28 | 0.12 | 0.10 | 0.32 | 0.18 | 0.00 |

CRoot = coarse roots; FRoot = fine roots

**Data Sources (Appendix Table E.2)**

Root:Shoot Ratios

Huisache: huisache seedling = 0.48 (Fulbright et al. 1997); *Leucaena leucocephala* seedling = 0.46 (Jones & Aliyu 1976; Huang et al. 1985); *Leucaena leucocephala* mature = 0.82 (Von Carlowitz & Wolf 1991); huisache mature = 0.82(0.48/0.46) = 0.85
Pecan: Slow-growing hardwoods (Odum 1971:375)
Sugar hackberry: *Fagus* sp. (Garelkov 1973)
Mesquite: Twice the value reported by Barth et al. (1982)
Post oak: Mean of *Quercus alba* (Nadelhoffer et al. 1985), *Q. rubra* (Nadelhoffer et al. 1985), *Q. robur* (Andersson 1970, Duvigneaud et al. 1971, Rodin & Bazilevich 1967), *Q. robus* (Duvigneaud et al. 1971), *Q. velutina* (Nadelhoffer et al. 1985)
Live oak: Mean of *Quercus alba* and *Q. velutina* (Nadelhoffer et al. 1985)

Coarse:Fine Root Ratios

Coarse:Fine 75:25 trees; 70:30 shrubs; 50:50 herbaceous

Aboveground Tissue Allocation (Trunk:Stem:Leaves)

Trees: 0.70:0.22:0.08
Shrubs: 0.55:0.30:0.15
Herbaceous (stemmy): 0.2:0.4:0.4
Herbaceous (short): 0.3:0.1:0.6

Appendix Table E.3 Allocation of new biomass production by plant part (proportion of total) for species included in the Victoria County EDYS model.

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.00 | 0.23 | 0.00 | 0.04 | 0.73 | 0.00 |
| Pecan | 0.00 | 0.24 | 0.00 | 0.05 | 0.71 | 0.00 |
| Hackberry | 0.00 | 0.12 | 0.00 | 0.06 | 0.82 | 0.00 |
| Mesquite | 0.00 | 0.15 | 0.00 | 0.10 | 0.75 | 0.00 |
| Post oak | 0.00 | 0.15 | 0.00 | 0.06 | 0.79 | 0.00 |
| Live oak | 0.00 | 0.18 | 0.00 | 0.05 | 0.77 | 0.00 |
| Blackbrush | 0.00 | 0.20 | 0.00 | 0.20 | 0.60 | 0.00 |
| Baccharis | 0.00 | 0.19 | 0.00 | 0.20 | 0.61 | 0.00 |
| Sea oxeye | 0.00 | 0.15 | 0.00 | 0.25 | 0.60 | 0.00 |
| Granjeno | 0.00 | 0.21 | 0.00 | 0.19 | 0.60 | 0.00 |
| McCartney rose | 0.00 | 0.15 | 0.00 | 0.25 | 0.60 | 0.00 |
| Rattlepod | 0.00 | 0.19 | 0.00 | 0.30 | 0.51 | 0.00 |
| Greenbriar | 0.00 | 0.10 | 0.00 | 0.20 | 0.70 | 0.00 |
| Mustang grape | 0.00 | 0.17 | 0.00 | 0.23 | 0.60 | 0.00 |
| Prickly pear | 0.10 | 0.15 | 0.05 | 0.69 | 0.01 | 0.00 |
| Big bluestem | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Bushy bluestem | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Purple threeawn | 0.00 | 0.19 | 0.00 | 0.03 | 0.78 | 0.00 |
| Arrowfeather threeawn | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Silver bluestem | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Sideoats grama | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Buffalograss | 0.00 | 0.20 | 0.00 | 0.09 | 0.71 | 0.00 |
| Sandbur | 0.00 | 0.40 | 0.00 | 0.25 | 0.35 | 0.00 |
| Hooded windmillgrass | 0.00 | 0.18 | 0.00 | 0.03 | 0.79 | 0.00 |
| Bermudagrass | 0.01 | 0.19 | 0.00 | 0.03 | 0.77 | 0.00 |
| Saltgrass | 0.00 | 0.35 | 0.00 | 0.38 | 0.27 | 0.00 |
| Virginia wildrye | 0.00 | 0.17 | 0.00 | 0.41 | 0.42 | 0.00 |
| Pan-American balsamscale | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Plains lovegrass | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Switchgrass | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Longtom | 0.00 | 0.26 | 0.00 | 0.03 | 0.71 | 0.00 |
| Brownseed paspalum | 0.00 | 0.15 | 0.00 | 0.40 | 0.45 | 0.00 |
| Thin paspalum | 0.00 | 0.16 | 0.00 | 0.05 | 0.79 | 0.00 |
| Common reed | 0.02 | 0.19 | 0.00 | 0.40 | 0.41 | 0.00 |

Appendix Table E.3 (Cont.)

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.01 | 0.18 | 0.00 | 0.40 | 0.41 | 0.00 |
| Knotroot bristelgrass | 0.01 | 0.19 | 0.00 | 0.05 | 0.75 | 0.00 |
| Plains bristlegrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Indiangrass | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Milo | 0.25 | 0.25 | 0.10 | 0.20 | 0.20 | 0.00 |
| Johnsongrass | 0.01 | 0.17 | 0.00 | 0.41 | 0.41 | 0.00 |
| Gulf cordgrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Tall dropseed | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Smutgrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Texas wintergrass | 0.00 | 0.19 | 0.00 | 0.03 | 0.78 | 0.00 |
| Littletooth sedge | 0.00 | 0.20 | 0.00 | 0.05 | 0.75 | 0.00 |
| Flatsedge | 0.00 | 0.26 | 0.00 | 0.20 | 0.54 | 0.00 |
| Olney bulrush | 0.00 | 0.10 | 0.00 | 0.56 | 0.34 | 0.00 |
| Cattail | 0.02 | 0.15 | 0.00 | 0.43 | 0.40 | 0.00 |
| Spiny aster | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |
| Ragweed | 0.00 | 0.15 | 0.00 | 0.43 | 0.42 | 0.00 |
| Wild indigo | 0.00 | 0.15 | 0.00 | 0.85 | 0.00 | 0.00 |
| Old-mans beard | 0.00 | 0.21 | 0.00 | 0.39 | 0.40 | 0.00 |
| Bundleflower | 0.00 | 0.14 | 0.00 | 0.43 | 0.43 | 0.00 |
| Mistflower | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Camphorweed | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |
| Frogfruit | 0.00 | 0.13 | 0.00 | 0.44 | 0.43 | 0.00 |
| Snoutbean | 0.00 | 0.15 | 0.00 | 0.43 | 0.42 | 0.00 |
| Ruellia | 0.00 | 0.14 | 0.00 | 0.21 | 0.65 | 0.00 |
| Glasswort | 0.00 | 0.10 | 0.15 | 0.05 | 0.70 | 0.00 |
| Bush sunflower | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Orange zexmenia | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Giant ragweed | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Partridge pea | 0.19 | 0.19 | 0.19 | 0.06 | 0.37 | 0.00 |
| Woolly doveweed | 0.14 | 0.15 | 0.14 | 0.29 | 0.28 | 0.00 |
| Broomweed | 0.19 | 0.19 | 0.12 | 0.25 | 0.25 | 0.00 |
| Sunflower | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Sumpweed | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |

Appendix Table E.4 Allocation of biomass production in green-out months by plant part (proportion of total) for species included in the Victoria County EDYS model.

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.00 | 0.23 | 0.00 | 0.04 | 0.73 | 0.00 |
| Pecan | 0.00 | 0.24 | 0.00 | 0.05 | 0.71 | 0.00 |
| Hackberry | 0.00 | 0.12 | 0.00 | 0.06 | 0.82 | 0.00 |
| Mesquite | 0.00 | 0.15 | 0.00 | 0.10 | 0.75 | 0.00 |
| Post oak | 0.00 | 0.15 | 0.00 | 0.06 | 0.79 | 0.00 |
| Live oak | 0.00 | 0.18 | 0.00 | 0.05 | 0.77 | 0.00 |
| Blackbrush | 0.00 | 0.20 | 0.00 | 0.20 | 0.60 | 0.00 |
| Baccharis | 0.00 | 0.19 | 0.00 | 0.20 | 0.61 | 0.00 |
| Sea oxeye | 0.00 | 0.15 | 0.00 | 0.25 | 0.60 | 0.00 |
| Granjeno | 0.00 | 0.21 | 0.00 | 0.19 | 0.60 | 0.00 |
| McCartney rose | 0.00 | 0.15 | 0.00 | 0.25 | 0.60 | 0.00 |
| Rattlepod | 0.00 | 0.19 | 0.00 | 0.30 | 0.51 | 0.00 |
| Greenbriar | 0.00 | 0.10 | 0.00 | 0.20 | 0.70 | 0.00 |
| Mustang grape | 0.00 | 0.17 | 0.00 | 0.23 | 0.60 | 0.00 |
| Prickly pear | 0.10 | 0.15 | 0.05 | 0.69 | 0.01 | 0.00 |
| Big bluestem | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Bushy bluestem | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Purple threeawn | 0.00 | 0.19 | 0.00 | 0.03 | 0.78 | 0.00 |
| Arrowfeather threeawn | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Silver bluestem | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Sideoats grama | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Buffalograss | 0.00 | 0.20 | 0.00 | 0.09 | 0.71 | 0.00 |
| Sandbur | 0.00 | 0.40 | 0.00 | 0.25 | 0.35 | 0.00 |
| Hooded windmillgrass | 0.00 | 0.18 | 0.00 | 0.03 | 0.79 | 0.00 |
| Bermudagrass | 0.01 | 0.19 | 0.00 | 0.03 | 0.77 | 0.00 |
| Saltgrass | 0.00 | 0.35 | 0.00 | 0.38 | 0.27 | 0.00 |
| Virginia wildrye | 0.00 | 0.17 | 0.00 | 0.41 | 0.42 | 0.00 |
| Pan-American balsamscale | 0.00 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 |
| Plains lovegrass | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Switchgrass | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Longtom | 0.00 | 0.26 | 0.00 | 0.03 | 0.71 | 0.00 |
| Brownseed paspalum | 0.00 | 0.15 | 0.00 | 0.40 | 0.45 | 0.00 |
| Thin paspalum | 0.00 | 0.16 | 0.00 | 0.05 | 0.79 | 0.00 |
| Common reed | 0.02 | 0.19 | 0.00 | 0.40 | 0.41 | 0.00 |

Appendix Table E.4 (Cont.)

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.01 | 0.18 | 0.00 | 0.40 | 0.41 | 0.00 |
| Knotroot bristelgrass | 0.01 | 0.19 | 0.00 | 0.05 | 0.75 | 0.00 |
| Plains bristlegrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Indiangrass | 0.01 | 0.18 | 0.00 | 0.41 | 0.40 | 0.00 |
| Milo | 0.25 | 0.25 | 0.10 | 0.20 | 0.20 | 0.00 |
| Johnsongrass | 0.01 | 0.17 | 0.00 | 0.41 | 0.41 | 0.00 |
| Gulf cordgrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Tall dropseed | 0.00 | 0.18 | 0.00 | 0.41 | 0.41 | 0.00 |
| Smutgrass | 0.00 | 0.15 | 0.00 | 0.53 | 0.32 | 0.00 |
| Texas wintergrass | 0.00 | 0.19 | 0.00 | 0.03 | 0.78 | 0.00 |
| Littletooth sedge | 0.00 | 0.20 | 0.00 | 0.05 | 0.75 | 0.00 |
| Flatsedge | 0.00 | 0.26 | 0.00 | 0.20 | 0.54 | 0.00 |
| Olney bulrush | 0.00 | 0.10 | 0.00 | 0.56 | 0.34 | 0.00 |
| Cattail | 0.02 | 0.15 | 0.00 | 0.43 | 0.40 | 0.00 |
| Spiny aster | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |
| Ragweed | 0.00 | 0.15 | 0.00 | 0.43 | 0.42 | 0.00 |
| Wild indigo | 0.00 | 0.15 | 0.00 | 0.85 | 0.00 | 0.00 |
| Old-mans beard | 0.00 | 0.21 | 0.00 | 0.39 | 0.40 | 0.00 |
| Bundleflower | 0.00 | 0.14 | 0.00 | 0.43 | 0.43 | 0.00 |
| Mistflower | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Camphorweed | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |
| Frogfruit | 0.00 | 0.13 | 0.00 | 0.44 | 0.43 | 0.00 |
| Snoutbean | 0.00 | 0.15 | 0.00 | 0.43 | 0.42 | 0.00 |
| Ruellia | 0.00 | 0.14 | 0.00 | 0.21 | 0.65 | 0.00 |
| Glasswort | 0.00 | 0.10 | 0.15 | 0.05 | 0.70 | 0.00 |
| Bush sunflower | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Orange zexmenia | 0.00 | 0.19 | 0.00 | 0.41 | 0.40 | 0.00 |
| Giant ragweed | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Partridge pea | 0.19 | 0.19 | 0.19 | 0.06 | 0.37 | 0.00 |
| Woolly doveweed | 0.14 | 0.15 | 0.14 | 0.29 | 0.28 | 0.00 |
| Broomweed | 0.19 | 0.19 | 0.12 | 0.25 | 0.25 | 0.00 |
| Sunflower | 0.16 | 0.17 | 0.13 | 0.27 | 0.27 | 0.00 |
| Sumpweed | 0.00 | 0.10 | 0.00 | 0.52 | 0.38 | 0.00 |

**General guidelines for greenout allocation:**

Trees: coarse roots, trunks, and seeds = no allocation; fine roots and stems = 75% of new growth allocation; leaves = remainder of allocation

Shrubs, midgrasses, and perennial forbs: coarse roots, trunks, and seeds = no allocation; fine roots = 75% of new growth allocation; stems + leaves = remainder of allocation (exception = rhizomatous grasses, which have coarse roots = 10% of new growth allocation)

Shortgrasses: coarse roots, trunks, and seeds = no allocation; fine roots = 75% of new growth allocation; stems = 50% of new growth allocation; leaves = remainder of allocation (exceptions = rhizomatous grasses which have coarse roots = 10% of new growth allocation and stoloniferous grasses which have stems = 75% of new growth allocation)

Annuals = 100% new growth allocations.

Appendix Table E.9 Root architecture, proportion of roots by maximum rooting depth, and maximum potential rooting depth (mm) for plant species included in the Victoria County EDYS model.

| Common Name | 0-1 | 1-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70-80 | 80-90 | 90-100 | Max Root Depth (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 6 | 11 | 14 | 18 | 15 | 12 | 8 | 6 | 4 | 3 | 2 | 1 | 5000 |
| Pecan | 4 | 9 | 14 | 20 | 13 | 5 | 6 | 6 | 2 | 6 | 8 | 7 | 6250 |
| Hackberry | 2 | 9 | 14 | 20 | 15 | 5 | 6 | 6 | 2 | 6 | 8 | 7 | 6000 |
| Mesquite | 25 | 14 | 13 | 12 | 9 | 7 | 5 | 5 | 4 | 3 | 2 | 1 | 53400 |
| Post oak | 2 | 8 | 9 | 18 | 15 | 11 | 11 | 6 | 5 | 5 | 5 | 5 | 5700 |
| Live oak | 4 | 14 | 15 | 21 | 12 | 8 | 8 | 7 | 4 | 4 | 2 | 1 | 22000 |
| Blackbrush | 3 | 9 | 13 | 19 | 15 | 12 | 9 | 7 | 4 | 4 | 3 | 2 | 5250 |
| Baccharis | 1 | 5 | 9 | 12 | 18 | 17 | 11 | 11 | 7 | 6 | 2 | 1 | 1900 |
| Sea oxeye | 4 | 6 | 15 | 20 | 15 | 12 | 10 | 6 | 5 | 3 | 2 | 2 | 2000 |
| Granjeno | 4 | 13 | 14 | 17 | 14 | 12 | 10 | 6 | 4 | 3 | 2 | 1 | 6680 |
| McCartney rose | 6 | 6 | 8 | 15 | 16 | 14 | 8 | 8 | 7 | 7 | 3 | 2 | 3700 |
| Rattlepod | 2 | 5 | 9 | 15 | 17 | 16 | 13 | 8 | 7 | 5 | 2 | 1 | 1380 |
| Greenbriar | 4 | 12 | 13 | 25 | 8 | 5 | 5 | 5 | 6 | 6 | 6 | 5 | 1500 |
| Mustang grape | 5 | 12 | 15 | 17 | 13 | 11 | 9 | 7 | 5 | 3 | 2 | 1 | 3660 |
| Prickly pear | 2 | 9 | 12 | 19 | 13 | 20 | 11 | 6 | 4 | 2 | 1 | 1 | 840 |
| Big bluestem | 20 | 18 | 22 | 10 | 9 | 5 | 5 | 4 | 3 | 2 | 1 | 1 | 3050 |
| Bushy bluestem | 5 | 10 | 20 | 16 | 14 | 12 | 10 | 8 | 2 | 1 | 1 | 1 | 720 |
| Purple threeawn | 4 | 7 | 10 | 15 | 18 | 15 | 14 | 8 | 5 | 2 | 1 | 1 | 1830 |
| Arrowfeather threeawn | 10 | 20 | 22 | 20 | 10 | 6 | 4 | 3 | 2 | 1 | 1 | 1 | 720 |
| Silver bluestem | 17 | 25 | 20 | 12 | 8 | 6 | 3 | 3 | 2 | 2 | 1 | 1 | 2380 |
| Sideoats grama | 12 | 20 | 23 | 21 | 12 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | 3960 |
| Buffalograss | 8 | 23 | 24 | 20 | 8 | 5 | 4 | 3 | 2 | 1 | 1 | 1 | 2160 |
| Sandbur | 10 | 20 | 25 | 12 | 7 | 6 | 5 | 5 | 4 | 3 | 2 | 1 | 350 |
| Hooded windmillgrass | 4 | 12 | 13 | 21 | 12 | 11 | 11 | 4 | 3 | 3 | 3 | 3 | 990 |
| Bermudagrass | 5 | 14 | 17 | 15 | 12 | 10 | 8 | 6 | 5 | 4 | 3 | 1 | 900 |
| Saltgrass | 10 | 20 | 22 | 20 | 10 | 6 | 4 | 3 | 2 | 1 | 1 | 1 | 720 |
| Virginia wildrye | 4 | 12 | 16 | 18 | 14 | 12 | 8 | 6 | 4 | 3 | 2 | 1 | 720 |
| Pan-American balsamscale | 10 | 20 | 22 | 20 | 10 | 6 | 4 | 3 | 2 | 1 | 1 | 1 | 720 |
| Plains lovegrass | 3 | 9 | 11 | 19 | 14 | 12 | 10 | 7 | 6 | 4 | 4 | 1 | 1200 |
| Switchgrass | 19 | 17 | 20 | 12 | 8 | 6 | 6 | 4 | 3 | 2 | 2 | 1 | 3350 |
| Longtom | 5 | 19 | 18 | 12 | 9 | 7 | 7 | 6 | 5 | 4 | 4 | 4 | 900 |
| Brownseed paspalum | 3 | 20 | 28 | 16 | 12 | 8 | 6 | 3 | 1 | 1 | 1 | 1 | 1000 |
| Thin paspalum | 3 | 12 | 15 | 24 | 13 | 10 | 7 | 6 | 4 | 3 | 2 | 1 | 1660 |
| Common reed | 2 | 9 | 11 | 23 | 9 | 9 | 8 | 8 | 7 | 6 | 5 | 3 | 3500 |

Appendix Table E.9 (Cont.)

| Common Name | 0-1 | 1-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70-80 | 80-90 | 90-100 | Max Root Depth (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 13 | 22 | 23 | 15 | 8 | 5 | 4 | 3 | 3 | 2 | 1 | 1 | 2440 |
| Knotroot bristelgrass | 4 | 14 | 16 | 18 | 14 | 10 | 8 | 6 | 5 | 2 | 2 | 1 | 1020 |
| Plains bristlegrass | 6 | 19 | 19 | 27 | 9 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 1600 |
| Indiangrass | 12 | 25 | 21 | 10 | 9 | 7 | 5 | 4 | 3 | 2 | 1 | 1 | 2430 |
| Milo | 2 | 6 | 9 | 18 | 17 | 14 | 12 | 9 | 7 | 3 | 2 | 1 | 1950 |
| Johnsongrass | 3 | 12 | 17 | 18 | 14 | 10 | 9 | 7 | 5 | 3 | 1 | 1 | 2410 |
| Gulf cordgrass | 10 | 20 | 25 | 12 | 7 | 6 | 5 | 5 | 4 | 3 | 2 | 1 | 3960 |
| Tall dropseed | 4 | 15 | 17 | 20 | 11 | 8 | 6 | 5 | 5 | 4 | 4 | 1 | 2130 |
| Smutgrass | 3 | 13 | 14 | 20 | 12 | 9 | 5 | 6 | 8 | 5 | 3 | 2 | 2100 |
| Texas wintergrass | 3 | 11 | 13 | 18 | 14 | 10 | 8 | 8 | 6 | 4 | 3 | 2 | 1950 |
| Littletooth sedge | 2 | 9 | 12 | 22 | 16 | 10 | 8 | 6 | 5 | 5 | 4 | 1 | 1310 |
| Flatsedge | 2 | 5 | 8 | 15 | 13 | 12 | 12 | 10 | 9 | 7 | 4 | 3 | 630 |
| Olney bulrush | 6 | 18 | 20 | 23 | 10 | 8 | 6 | 4 | 2 | 1 | 1 | 1 | 600 |
| Cattail | 3 | 12 | 13 | 18 | 10 | 9 | 8 | 8 | 7 | 6 | 4 | 2 | 1400 |
| Spiny aster | 15 | 20 | 25 | 25 | 5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3100 |
| Ragweed | 6 | 20 | 20 | 27 | 10 | 4 | 3 | 3 | 2 | 2 | 2 | 1 | 1830 |
| Wild indigo | 10 | 24 | 20 | 24 | 9 | 4 | 3 | 2 | 1 | 1 | 1 | 1 | 1700 |
| Old-mans beard | 3 | 9 | 13 | 24 | 16 | 9 | 7 | 6 | 4 | 3 | 3 | 3 | 1280 |
| Bundleflower | 3 | 9 | 14 | 23 | 12 | 5 | 4 | 5 | 9 | 7 | 6 | 3 | 2100 |
| Mistflower | 10 | 14 | 18 | 23 | 11 | 6 | 5 | 4 | 3 | 3 | 2 | 1 | 2620 |
| Camphorweed | 8 | 20 | 25 | 32 | 5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3100 |
| Frogfruit | 2 | 6 | 8 | 14 | 12 | 11 | 14 | 11 | 11 | 5 | 4 | 2 | 690 |
| Snoutbean | 5 | 12 | 20 | 15 | 8 | 4 | 2 | 3 | 10 | 12 | 6 | 3 | 1350 |
| Ruellia | 4 | 4 | 7 | 19 | 20 | 14 | 11 | 7 | 6 | 4 | 3 | 1 | 1500 |
| Glasswort | 8 | 16 | 16 | 24 | 12 | 8 | 6 | 4 | 2 | 2 | 1 | 1 | 457 |
| Bush sunflower | 10 | 14 | 18 | 23 | 11 | 6 | 5 | 4 | 3 | 3 | 2 | 1 | 2620 |
| Orange zexmenia | 3 | 8 | 13 | 30 | 11 | 8 | 7 | 7 | 5 | 4 | 3 | 1 | 2640 |
| Giant ragweed | 2 | 6 | 11 | 23 | 10 | 9 | 9 | 9 | 8 | 7 | 4 | 2 | 1970 |
| Partridge pea | 2 | 8 | 10 | 15 | 14 | 10 | 8 | 11 | 8 | 6 | 5 | 3 | 850 |
| Woolly doveweed | 3 | 13 | 8 | 16 | 13 | 14 | 10 | 7 | 5 | 4 | 4 | 3 | 320 |
| Broomweed | 4 | 17 | 9 | 17 | 12 | 14 | 8 | 7 | 4 | 3 | 3 | 2 | 1050 |
| Sunflower | 6 | 24 | 6 | 9 | 12 | 16 | 10 | 7 | 2 | 3 | 3 | 2 | 3100 |
| Sumpweed | 8 | 20 | 25 | 32 | 5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3100 |

## Data Sources (Appendix Table E.9)

### Root Architecture

| | |
|---|---|
| Huisache | mean of *Leucaena leucocephala* (Toky & Bisht 1992) and *Prosopis glandulosa* |
| Pecan, sugar hackberry | *Acer saccharum* (Dawson 1993) |
| Mesquite | mean of Heitschmidt et al. (1988) and Montana et al. (1995) |
| Post oak | *Quercus havardii* (Sears et al. 1986) |
| Live oak | mean of *Acer saccharum* (Dawson 1993), *Leucaena leucocephala* (Toky & Bisht 1992), *Nothofagus antarctica* and *N. pumila* (Schulze et al. 1996), *Populus fremontii* (McLendon 2008), *Prosopis glandulosa, Quercus havardii* (Sears et al. 1986) |
| | |
| Blackbrush | mean of *Flourensia cernua* (Wallace et al. 1980) and *Larrea tridentata* (Wallace et al. 1980; Moorhead et al. 1989; Montana et al. 1995; Ogle et al. 2004) |
| Prairie baccharis | *Pulchea sericea* (Gary 1963) |
| Granjeno | mean of *Flourensia cernua* (Wallace et al. 1980) and *Prosopis glandulosa* |
| Rattlepod | mean of *Leucaena leucocephala* (Toky & Bisht 1992) and *Pulchea sericea* (Gary 1963) |
| Mustang grape | mean of 25 shrubs |
| Prickly pear | mean of *Opuntia acanthocarpa* (Nobel & Bobich 2002), *O. humifusa* (Sperry 1935), and *O. polyacantha* (Dougherty 1986) |
| | |
| Big bluestem | Sperry (1935), Weaver & Zink (1946), Weaver & Darland (1949), Coupland & Bradshaw (1953); Hopkins (1953), Weaver (1954) |
| Purple threeawn | modified from Weaver & Clements (1938) |
| Silver bluestem | mean of *Bouteloua curtipendula* and *Schizachyrium scoparium* |
| Sideoats grama | Weaver & Darland (1949), Hopkins (1953), Weaver (1954) |
| Buffalograss | Weaver & Clements (1938), Weaver & Darland (1949), Hopkins (1953) |
| Sandbur | mean of *Aristida purpurea* (Weaver & Clements 1938) and *Sporobolus cryptandrus* (Albertson 1937; Weaver & Darland 1949; Hopkins 1953) |
| Hooded windmill | mean of *Axonopus compressus* (Fiala & Herrera 1988) and *Sporobolus cryptandrus* (Albertson 1937; Weaver & Darland 1949; Hopkins 1953) |
| Bermudagrass | mean of *Axonopus compressus* (Fiala & Herrera 1988)*, Distichlis spicata* (Seliskar 1983; Dahlgren et al. 1997; McLendon 2008), *Hilaria mutica* (Montana et al. 1995) |
| Virginia wildrye | mean of *Agropyron trachycaulum* and *Poa compressa* (McLendon 2001) |
| Switchgrass | Weaver & Darland (1949), Hopkins (1953), Pettit & Jaynes (1971) |
| Longtom | mean of *Distichlis spicata* (Seliskar 1983; Dahlgren et al. 1997; McLendon 2008) and *Paspalum notatum* (Hernandez & Fiala 1992) |
| Thin paspalum | mean of *Andropogon gerardii* var. *paucipilus* (Weaver & Clements 1938), *Cenchrus ciliaris* (Chaieb et al. 1996), *Redfieldia flexuosa* (Weaver & Clements 1938), *Sporobolus cryptandrus* (Albertson 1937; Weaver & Darland 1949; Hopkins 1953), and *Schzachyrium scoparium* |
| Little bluestem | Sperry (1935), Weaver & Zink (1946), Weaver (1947, 1950, 1954, 1958), Weaver & Darland (1949), Coupland & Bradshaw (1953), Jurena & Archer (2003) |
| Knotroot bristlegrass | mean of *Bouteloua curtipendula* (Weaver & Darland 1949; Hopkins 1953; Weaver 1954; Pettit & Jayens 1971) and *Sporobolus airoides* (McLendon 2008) |
| Johnsongrass | mean of *Panicum virgatum* (Weaver & Darland 1949; Hopkins 1953; Pettit & Jaynes 1971) and *Zea mays* (Weaver & Clements 1938) |
| Tall dropseed | mean of *Muhlenbergia cuspidata* (Sperry 1935), *Schizachyrium scoparium* (Sperry 1935; Weaver & Zink 1946; Weaver 1947, 1950, 1954, 1958; Weaver & Darland 1949; Coupland & Bradshaw 1953; Jurena & Archer 2003), *Sporobolus cryptandrus* (Albertson 1937; Weaver & Darland 1949; Hopkins 1953) |
| Texas wintergrass | mean of *Stipa comata* (Melgoza & Nowak 1991), *S. lagascae* (Chaieb et al. 1996), *S. spartea* (Sperry 1935; Coupland & Bradshaw 1953) |
| Milo | mean of *Triticum aestivum* and *Zea mays* |

| | |
|---|---|
| Littletooth sedge | mean of *Carex douglasii* (Manning et al. 1989) and *C. varia* (Sperry 1935) |
| Flatsedge | mean of *Carex nebrascensis* (Manning et al. 1989; Svejcar & Trent 1995; Kauffman et al. 2004) and *Scirpus validus* (Weaver & Clements 1938) |
| Cattail | mean of *Carex nebrascensis* (Manning et al. 1989), *Distichlis spicata* (Seliskar 1983; Dahlgren et al. 1997; McLendon 2008), *Lepidium latifolium* (Renz et al. 1997), *Paspalum notatum* (Hernandez & Fiala 1992), *Scirpus validus* (Weaver & Clements 1938), *Spartina pectinata* (Sperry 1935) |
| | |
| Ragweed | Sperry (1935) |
| Old-mans beard | mean of *Achillea millefolium* and *Solidago decumbens* (Holch et al. 1941) |
| Bundleflower | mean of *Oxytropis lambertii* (Weaver & Clements 1938), *Petalostemum purpureum* (Sperry 1935), and *Potentilla diversifolis* and *P. gracilis* (Holch et al. 1941) |
| Frogfruit | mean of *Potentilla gracilis* (Holch et al. 1941), *Pycanthemum tenuifolium* (Sperry 1935) |
| Prairie coneflower | *Ratibida pinnata* (Sperry 1935) |
| Snoutbean | *Petalostemum purpureum* (Sperry 1935) |
| Ruellia | *Ruellia humilis* (Sperry 1935) |
| Bush sunflower | *Helianthus scaberriums* (Sperry 1935) |
| Orange zexmenia | mean of *Helianthus scaberriums* and *Parthenium hispidum* (Sperry 1935) |
| Giant ragweed | mean of *Ambrosia psilostachya* and *Parthenium hispidum* (Sperry 1935) |
| Partridge pea | mean of *Erysimum asperum* (Holch et al. 1941), *Euphorbia corollata* (Sperry 1935) |
| Texas doveweed | mean of *Centaurea maculosa* (Marier et al. 1999), *Grindelia squarrosa* (Holch et al. 1941), *Helianthus annuus* (Stone et al. 2001) |
| Sunflower | Stone et al. (2001) |

**Maximum Potential Rooting Depth**

| | |
|---|---|
| Huisache | mean of *Chilopsis linearis* (Meinzer 1927), *Prosopis velutina* (Snyder & Williams 2003) |
| Pecan | mean of *Celtis laevigata* (Jackson et al. 1999), *Juglans nigra* (Canadell et al. 1996), *Ulmus americana* (Jackson et al. 1999), *Ulmus crassifolia* (Jackson et al. 1999) |
| Sugar hackberry | Jackson et al. (1999) |
| Mesquite | Phillips (1963) |
| Post oak | mean of *Quercus durandii* (Jackson et al. 1999) and *Q. macrocarpa* (Biswell 1935) |
| Live oak | Jackson et al. (1999) |
| | |
| Blackbrush | mean of *Koeberlinia spinosa* (Gibbens & Lenz 2001), *Larrea tridentata* (Gile et al. 1998) |
| Prairie baccharis | mean of *Baccharis glutinosa* (Gary 1963), *B. pilularis* (Wright 1928) |
| Granjeno | mean of *Arctostaphylos glandulosa* (Hellmers et al. 1955), *Celtis laevigata* (Jackson et al. 1999), *Flourensia cernua* (Gibbens & Lenz 2001), *Koeberlinia spinosa* (Gibbens & Lenz 2001), *Larrea tridentata* (Gile et al. 1998), *Lycium berlandieri* (Gibbens & Lenz 2001), *Sarcobatus vermiculatus* (Meinzer 1927) |
| Rattlepod | mean of *Baccharis glutinosa* (Gary 1963), *Pulchea sericea* (Gary 1963), *Sesbania sesban* (Sekiya & Yano 2002) |
| Greenbriar | *Smilax rotundiflora* (Duncan 1935) |
| Mustang grape | *Toxicodendron radicans* (Tolstead 1942) |
| Prickly pear | mean of *Opuntia imbricata* (Dittmer 1959), *O. polyacantha* (Tierney & Foxx 1987) |
| | |
| Big bluestem | Tomanek & Albertson (1957) |
| Purple threeawn | Albertson (1937) |
| Silver bluestem | mean of *Bouteloua curtipendula* (Tomanek & Albertson 1957), *Heteropogon contortus* (Cable 1980), *Schizachyrium scoparium* (Weaver & Fitzpatrick 1934), *Sporobolus asper* (Weaver & Albertson 1943) |
| Sideoats grama | Tomanek & Albertson (1957) |
| Buffalograss | Weaver & Clements (1938) |
| Sandbur | Dittmer (1959) |
| Hooded windmillgrass | mean of *Bouteloua hirsuta* (Weaver 1926), *Cenchrus incertus* (Dittmer 1959), |

| | |
|---|---|
| | *Digitaria californica* (Cable 1980), *Hilaria jamesii* (Weaver 1958), *Muhlenbergia torreyi* (Weaver 1958), *Scleropogon brevifolius* (Gibbens & Lenz 2001) |
| Bermudagrass | Garrot & Mancino (1994) |
| Virginia wildrye | *Elymus canadensis* (Weaver 1958) |
| Switchgrass | Weaver (1954) |
| Longtom | mean of *Cynodon dactylon* (Garrot & Mancino 1994), *Distichlis spicata* (Shantz & Piemeisel 1940), and *Holcus lanatus* and *Nardus stricta* (Boggie et al. 1958) |
| Thin paspalum | mean of *Heteropogon contortus* (Cable 1980), *Muhlenbergia arenacea* (Gibbens & Lenz 2001), *Redfieldia flexuosa* (Weaver 1958), *Schizachyrium scoparium* (Weaver & Fitzpatrick 1934), *Sporobolus asper* (Weaver & Albertson 1943) |
| Little bluestem | Weaver & Fitzpatrick (1934) |
| Knotroot bristlegrass | mean of *Agrostis tenuis* (Boggie et al. 1958), *Dichanthelium scribnerianum* (Weaver 1954), *Muhlenbergia torreyi* (Weaver 1958), *Poa pratensis* (Weaver 1954) |
| Johnsongrass | mean of *Sorghastrum nutans* (Albertson 1937) and *Zea mays* (Weaver 1926) |
| Tall dropseed | Weaver & Albertson (1943) |
| Texas wintergrass | *Stipa comata* (Wyatt et al. 1980) |
| Milo | mean of *Pennisetum glaucum* (Payne et al. 1990) and *Zea mays* (Weaver 1926) |
| | |
| Littletooth sedge | mean of *Carex filifolia* (Weaver 1920; Tolstead 1942), *C. geyerii* (Spence 1937), *C. varia* (Sperry 1935) |
| Flatsedge | mean of *Carex nebrascensis* (Chambers et al. 1999), *Juncus balticus* (Manning et al. 1989), *Scirpus validus* (Weaver & Clements 1938) |
| Cattail | mean of *Lepidium latifolium* (Renz et al. 1997), *Scirpus validus* (Weaver & Clements 1938), *Spartina pectinata* (Weaver 1958) |
| | |
| Ragweed | Weaver (1958) |
| Old-mans beard | mean of *Achillea millefolium* (Spence 1937), *Smilax rotundifolia* (Duncan 1935) |
| Bundleflower | *Desmanthus cooleyi* (Gibbens & Lenz 2001) |
| Frogfruit | mean of *Euphorbia albomarginata* (Gibbens & Lenz 2001), *Evolvulus nuttallianus* (Albertson 1937), *Hedyotis nigricans* (Albertson 1937) |
| Prairie coneflower | Hopkins (1951) |
| Snoutbean | mean of *Cassia bauhinioides* (Gibbens & Lenz 2001), *Desmanthus cooleyi* (Gibbens & Lenz 2001), *Hoffmanseggia drepanocarpa* (Gibbens & Lenz 2001), *Thermopsis rhombifolia* (Coupland & Johnson 1965), *Trifolium pretense* (Keim & Beadle 1927) |
| Ruellia | *Ruellia caroliniensis* (Sperry 1935) |
| Bush sunflower | mean of *Arnica pumila* (Holch et al. 1941), *Balsamorhiza sagittata* (Weaver 1958), *Chrysopsis villosa* (Weaver 1958), *Helianthus laetiflorus* (Weaver 1954), *Parthenium integrifolium* (Sperry 1935), *Veronica baldwinii* (Weaver 1919) |
| Orange zexmenia | mean of *Artemisia dracunculus* (Foxx & Tierney 1986), *Chrysopsis villosa* (Weaver 1958), *Helianthus laetiflorus* (Weaver 1954), *Machaeranthera pinnatifida* (Hopkins 1951), *Parthenium integrifolium* (Sperry 1935) |
| | |
| Giant ragweed | mean of *Ambrosia acanthicarpa* (Dittmer 1959), *A. artemisifolia* (Cole & Holch 1941), *Helianthus annuus* (Schwarzbach et al. 2001), *Kochia scoparia* (Foxx & Tierney 1986) |
| Partridge pea | *Cassia bauhinioides* (Gibbens & Lenz 2001) |
| Texas doveweed | Dittmer (1959) |
| Sunflower | Schwarzbach et al. (2001) |

Appendix Table E.11 Values for months when physiological responses occur in plant species included in the Victoria County EDYS model.

| Common Name | Green-out | Seed-sprout | | Seed-set | | Dormancy |
|---|---|---|---|---|---|---|
| Huisache | 2 | 2 | 9 | 4 | 9 | 12 |
| Pecan | 3 | 3 | 9 | 4 | 9 | 10 |
| Hackberry | 3 | 3 | 9 | 4 | 8 | 10 |
| Mesquite | 3 | 3 | 9 | 4 | 8 | 11 |
| Post oak | 3 | 3 | 7 | 4 | 8 | 11 |
| Live oak | 3 | 3 | 7 | 4 | 8 | 2 |
| Blackbrush | 2 | 2 | 10 | 6 | 10 | 12 |
| Baccharis | 2 | 2 | 10 | 2 | 10 | 11 |
| Sea oxeye | 4 | 3 | 9 | 4 | 8 | 10 |
| Granjeno | 3 | 2 | 10 | 4 | 8 | 11 |
| McCartney rose | 3 | 3 | 9 | 4 | 8 | 1 |
| Rattlepod | 3 | 2 | 10 | 6 | 7 | 11 |
| Greenbriar | 3 | 9 | 6 | 2 | 6 | 2 |
| Mustang grape | 2 | 3 | 9 | 6 | 10 | 12 |
| Prickly pear | 1 | 2 | 11 | 7 | 8 | 12 |
| Big bluestem | 3 | 4 | 8 | 8 | 8 | 11 |
| Bushy bluestem | 3 | 4 | 4 | 8 | 8 | 11 |
| Purple threeawn | 3 | 4 | 9 | 7 | 11 | 12 |
| Arrowfeather threeawn | 4 | 4 | 4 | 8 | 8 | 10 |
| Silver bluestem | 3 | 3 | 9 | 5 | 7 | 11 |
| Sideoats grama | 3 | 4 | 9 | 6 | 10 | 11 |
| Buffalograss | 3 | 3 | 9 | 5 | 10 | 11 |
| Sandbur | 3 | 4 | 9 | 7 | 8 | 11 |
| Hooded windmillgrass | 3 | 3 | 10 | 7 | 8 | 11 |
| Bermudagrass | 3 | 4 | 10 | 5 | 8 | 11 |
| Saltgrass | 3 | 3 | 9 | 5 | 7 | 11 |
| Virginia wildrye | 10 | 10 | 6 | 5 | 7 | 6 |
| Pan-American balsamscale | 4 | 4 | 4 | 8 | 8 | 10 |
| Plains lovegrass | 3 | 4 | 9 | 6 | 9 | 10 |
| Switchgrass | 3 | 5 | 9 | 7 | 9 | 11 |
| Longtom | 3 | 3 | 10 | 8 | 10 | 11 |
| Brownseed paspalum | 3 | 3 | 8 | 8 | 10 | 10 |
| Thin paspalum | 3 | 3 | 10 | 8 | 9 | 11 |
| Common reed | 3 | 4 | 10 | 9 | 11 | 11 |

Appendix Table E.11 (Cont.)

| Common Name | Green-out | Seed-sprout | | Seed-set | | Dormancy |
|---|---|---|---|---|---|---|
| Little bluestem | 3 | 5 | 9 | 7 | 9 | 11 |
| Knotroot bristelgrass | 3 | 3 | 10 | 5 | 8 | 12 |
| Plains bristlegrass | 3 | 3 | 9 | 5 | 8 | 11 |
| Indiangrass | 3 | 5 | 9 | 7 | 9 | 11 |
| Milo | 3 | 3 | 9 | 5 | 8 | 11 |
| Johnsongrass | 3 | 4 | 9 | 7 | 10 | 11 |
| Gulf cordgrass | 3 | 3 | 9 | 5 | 8 | 11 |
| Tall dropseed | 3 | 4 | 9 | 5 | 8 | 11 |
| Smutgrass | 3 | 3 | 9 | 5 | 8 | 11 |
| Texas wintergrass | 10 | 10 | 5 | 3 | 5 | 6 |
| Littletooth sedge | 3 | 3 | 10 | 5 | 9 | 12 |
| Flatsedge | 2 | 3 | 10 | 4 | 9 | 12 |
| Olney bulrush | 3 | 3 | 9 | 5 | 8 | 11 |
| Cattail | 3 | 4 | 10 | 6 | 8 | 12 |
| Spiny aster | 3 | 4 | 9 | 6 | 8 | 9 |
| Ragweed | 3 | 3 | 9 | 5 | 10 | 10 |
| Wild indigo | 3 | 3 | 9 | 5 | 8 | 11 |
| Old-mans beard | 3 | 3 | 10 | 6 | 10 | 12 |
| Bundleflower | 3 | 4 | 9 | 5 | 10 | 11 |
| Mistflower | 3 | 3 | 9 | 5 | 9 | 11 |
| Camphorweed | 3 | 4 | 9 | 6 | 8 | 9 |
| Frogfruit | 3 | 3 | 9 | 3 | 10 | 11 |
| Snoutbean | 3 | 3 | 9 | 4 | 8 | 11 |
| Ruellia | 3 | 3 | 10 | 4 | 8 | 12 |
| Glasswort | 2 | 3 | 8 | 5 | 9 | 10 |
| Bush sunflower | 3 | 3 | 9 | 5 | 9 | 11 |
| Orange zexmenia | 3 | 4 | 9 | 5 | 9 | 11 |
| Giant ragweed | 3 | 3 | 9 | 7 | 8 | 11 |
| Partridge pea | 3 | 3 | 9 | 6 | 7 | 11 |
| Woolly doveweed | 3 | 2 | 9 | 4 | 8 | 11 |
| Broomweed | 3 | 2 | 9 | 3 | 10 | 11 |
| Sunflower | 2 | 2 | 10 | 5 | 9 | 11 |
| Sumpweed | 3 | 4 | 9 | 6 | 8 | 9 |

Appendix Table E.13 Values for water use variables used in the Victoria County EDYS model.

| Common Name | Maintenance (mm/g bio/mo) | New biomass maintenance | Water to production | Green-out water use |
|---|---|---|---|---|
| Huisache | 0.000009 | 0.04 | 1.25 | 0.55 |
| Pecan | 0.000009 | 0.04 | 0.88 | 0.55 |
| Hackberry | 0.000009 | 0.05 | 0.90 | 0.45 |
| Mesquite | 0.000009 | 0.04 | 1.10 | 0.50 |
| Post oak | 0.000008 | 0.04 | 0.90 | 0.45 |
| Live oak | 0.000008 | 0.03 | 0.80 | 0.45 |
| Blackbrush | 0.000009 | 0.05 | 1.63 | 0.70 |
| Baccharis | 0.000009 | 0.05 | 0.81 | 0.70 |
| Sea oxeye | 0.000010 | 0.05 | 1.87 | 0.50 |
| Granjeno | 0.000010 | 0.05 | 1.22 | 0.50 |
| McCartney rose | 0.000009 | 0.05 | 1.30 | 0.65 |
| Rattlepod | 0.000025 | 0.07 | 0.64 | 0.75 |
| Greenbriar | 0.000018 | 0.05 | 1.20 | 0.61 |
| Mustang grape | 0.000009 | 0.05 | 0.90 | 0.70 |
| Prickly pear | 0.000008 | 0.04 | 0.30 | 0.80 |
| Big bluestem | 0.000028 | 0.05 | 0.83 | 0.80 |
| Bushy bluestem | 0.000028 | 0.05 | 1.30 | 0.80 |
| Purple threeawn | 0.000015 | 0.04 | 0.68 | 0.65 |
| Arrowfeather threeawn | 0.000028 | 0.05 | 1.30 | 0.80 |
| Silver bluestem | 0.000016 | 0.04 | 0.76 | 0.70 |
| Sideoats grama | 0.000016 | 0.04 | 0.87 | 0.65 |
| Buffalograss | 0.000015 | 0.04 | 0.74 | 0.64 |
| Sandbur | 0.000391 | 0.05 | 0.47 | 0.80 |
| Hooded windmillgrass | 0.000391 | 0.05 | 0.87 | 0.80 |
| Bermudagrass | 0.000016 | 0.04 | 0.91 | 0.70 |
| Saltgrass | 0.000016 | 0.04 | 0.78 | 0.70 |
| Virginia wildrye | 0.000016 | 0.04 | 1.24 | 0.70 |
| Pan-American balsamscale | 0.000028 | 0.05 | 1.30 | 0.80 |
| Plains lovegrass | 0.000016 | 0.04 | 0.79 | 0.70 |
| Switchgrass | 0.000018 | 0.05 | 1.00 | 0.75 |
| Longtom | 0.000002 | 0.06 | 1.00 | 0.65 |
| Brownseed paspalum | 0.000002 | 0.06 | 0.95 | 0.65 |
| Thin paspalum | 0.000002 | 0.06 | 0.76 | 0.65 |
| Common reed | 0.000020 | 0.06 | 0.73 | 0.70 |

Appendix Table E.13 (Cont.)

| Common Name | Maintenance (mm/g bio/mo) | New biomass maintenance | Water to production | Green-out water use |
|---|---|---|---|---|
| Little bluestem | 0.000017 | 0.05 | 0.90 | 0.65 |
| Knotroot bristelgrass | 0.000012 | 0.04 | 0.90 | 0.70 |
| Plains bristlegrass | 0.000012 | 0.04 | 0.80 | 0.70 |
| Indiangrass | 0.000018 | 0.05 | 0.89 | 0.75 |
| Milo | 0.000012 | 0.04 | 0.33 | 0.70 |
| Johnsongrass | 0.000018 | 0.06 | 0.89 | 0.70 |
| Gulf cordgrass | 0.000012 | 0.04 | 0.60 | 0.70 |
| Tall dropseed | 0.000016 | 0.04 | 0.71 | 0.70 |
| Smutgrass | 0.000012 | 0.04 | 0.60 | 0.70 |
| Texas wintergrass | 0.000012 | 0.03 | 0.99 | 0.65 |
| Littletooth sedge | 0.000020 | 0.06 | 0.79 | 0.67 |
| Flatsedge | 0.000020 | 0.06 | 0.85 | 0.70 |
| Olney bulrush | 0.000020 | 0.05 | 1.20 | 0.67 |
| Cattail | 0.000023 | 0.06 | 0.85 | 0.70 |
| Spiny aster | 0.000010 | 0.04 | 0.50 | 0.78 |
| Ragweed | 0.000014 | 0.03 | 0.91 | 0.72 |
| Wild indigo | 0.000019 | 0.05 | 1.10 | 0.67 |
| Old-mans beard | 0.000009 | 0.05 | 0.80 | 0.70 |
| Bundleflower | 0.000014 | 0.03 | 0.67 | 0.72 |
| Mistflower | 0.000020 | 0.07 | 0.85 | 0.75 |
| Camphorweed | 0.000010 | 0.04 | 0.50 | 0.78 |
| Frogfruit | 0.000007 | 0.03 | 0.70 | 0.72 |
| Snoutbean | 0.000025 | 0.08 | 0.83 | 0.82 |
| Ruellia | 0.000025 | 0.08 | 0.60 | 0.82 |
| Glasswort | 0.000019 | 0.06 | 0.80 | 0.67 |
| Bush sunflower | 0.000020 | 0.07 | 0.85 | 0.75 |
| Orange zexmenia | 0.000018 | 0.05 | 0.70 | 0.60 |
| Giant ragweed | 0.000007 | 0.03 | 0.53 | 0.72 |
| Partridge pea | 0.000025 | 0.07 | 0.76 | 0.75 |
| Woolly doveweed | 0.000025 | 0.08 | 0.56 | 0.82 |
| Broomweed | 0.000007 | 0.03 | 0.58 | 0.72 |
| Sunflower | 0.000020 | 0.06 | 0.55 | 0.70 |
| Sumpweed | 0.000010 | 0.04 | 0.50 | 0.78 |

**Data Sources (Appendix Table E.13)**

**Water to Production**

Huisache: mean of *Cercidium microphylum* and *Prosopis velutina* (McGinnes & Arnold 1939)
Pecan, sugar hackberry, post oak, live oak: *Populus fremontii* (Anderson 1982)
Mesquite: Dwyer & DeGarmo (1970)

Blackbrush: *Acacia greggii, Cercidium microphylum, Prosopis velutina* (McGinnes & Arnold 1939)
Baccharis: 0.9(*Populus fremontii*) = *Baccharis salicifolia* (Glenn et al. 1998)
Granjeno: mean of *Atriplex canescens* (Watson 1990), *Larrea tridentata* (Dwyer & DeGarmo 1970), *Populus fremontii* (Anderson 1982)
Rattlepod: mean of *Atriplex lentiformis* (Watson 1990), *Baccharis salicifolia* (Glenn et al. 1998), *Salix goodingii* (Glenn et al. 1998)
Mustang grape: *Populus fremontii* (Anderson 1982)
Prickly pear: *Opuntia basilaris* (Nobel 1976)

Big bluestem: Weaver (1941)
Purple threeawn: McLendon et al. (unpublished)
Silver bluestem: McGinnes & Arnold (1939)
Sideoats grama: McGinnes & Arnold (1939)
Buffalograss: 90% of blue grama (Shantz & Piemeisel 1927)
Sandbur: *Cenchrus ciliaris,* mean of Khan (1971) and Kapinga (1982)
Hooded windmillgrass and trichloris: *Chloris gayana* (Kapinga 1982)
Bermudagrass: mean of McDonald & Hughes (1968) and Wiedenfeld (1988)
Virginia wildrye: *Leymus junceus*, mean of Hunt (1962), Power (1985), Frank & Berdahl (1999)
Switchgrass: mean of *Andropogon gerardii* (Weaver 1941), *Panicum antidotale* (Writht & Dobrenz 1970)
Longtom: *Paspalum vaginatum* (Biran et al. 1981)
Thin paspalum: mean of *Aristida purpurea* (McLendon et al., unpublished), *Bouteloua hirsuta* (McGinnes & Arnold), *Cenchrus ciliaris* (Kapinga 1982), *Eragrostis curvula* (Wiedenfield 1988), *Heteropogon contortus* (McGinnes & Arnold 1939), *Schizachyrium scoparium* (Weaver 1941), *Sporobolus airoides* (Benton & Wester 1998), *Sporobolus flexuous* (Dwyer & DeGarmo)
Common reed: Mueller et al. (2005)
Little bluestem: mean of Weaver (1941) and McLendon et al. (unpublished)
Knotroot bristle: mean of *Spartina alterniflora* (Gallagher et al. 1980) and *Sporobolus wrightii* (Cox 1985)
Johnsongrass: mean of *Andropogon gerardii* (Weaver 1941), *Chloris gayana* (Kapinga 1982), *Panicum antidotale* (Wright & Dobrenz), *Phragmites australis* (Mueller et al. 2005), *Sorghum bicolor* (Briggs & Shantz 1913)
Tall dropseed: *Sporobolus flexuosus* (Dwyer & DeGarmo 1970)
Texas wintergrass: *Stipa viridula* (Fairbourn 1982)
Milo: Briggs & Shantz (1913), Peng & Krieg (1992)

Littletooth sedge: *Juncus roemerianus* (Giurgevich & Dunn 1978)
Flatsedge: *Phragmites australis* (Mueller et al. 2005)
Cattail: mean of *Juncus roemerianus* (Giurgevich & Dunn 1978), *Paspalum vaginatum* (Biran et al. 1981), *Phalaris aquatica* (Morison & Gifford 1984), *Phragmites australis* (Mueller et al. 2005), *Spartina alterniflora* (Gallagher et al. 1980)

Ragweed: *Ambrosia artemisifolia* (Shantz & Piemeisel 1927)
Old-mans beard: mean of *Ambrosia artemisifolia* and *Iva xanthifolia* (Shantz & Piemeisel 1927)
Bundleflower: mean of *Lotus humistrautis* (McGinnes & Arnold 1939), *Melilotus alba* (Shantz & Piemeisel 1927)
Frogfruit: mean of *Amaranthus retroflexus* (Briggs & Shantz 1913), *Plantago insularis* (McGinnes & Arnold 1939), *Polygonum aviculare* (Shantz & Piemeisel 1927)
Prairie coneflower: mean of *Ambrosia artemisifolia, Grindelia squarrosa*, *Helianthus petiolaris*, *Polygonum aviculare* (Shantz & Piemeisel 1927)

Snoutbean: mean of *Glycine max* (Lawn 1982), *Lotus humistrautis* (McGinnes & Arnold 1939), *Pisum sativum* (Briggs & Shantz 1913)
Ruellia: mean of *Fagopyrum fagopyrum* (Briggs & Shantz 1913), *Iva xanthifolia* (Shantz & Piemeisel 1927), *Plantago insularis* (McGinnes & Arnold 1939), *Polygonum aviculare* (Shantz & Piemeisel 1927), *Solanum tuberosum* (Briggs & Shantz 1913)
Bush sunflower: mean of *Helianthus petiolaris* and *Polygonum aviculare* (Shantz & Piemeisel 1927)
Orange zexmenia: 0.8(bush sunflower)

Giant ragweed: mean of *Amaranthus retroflexus* (Briggs & Shantz 1913), *Helianthus annuus* (mean of 4 studies), *Iva xanthifolia* (Shantz & Piemeisel 1927), *Polygonum aviculare* (Shantz & Piemeisel 1927)
Sunflower: mean of Shantz & Piemeisel (1927), Morison & Gifford (1984), Larcher (1995), Mueller et al. (2005)
Partridge pea: mean of *Astragalus cicer* (Fairbourn 1982), *Lotus humistrautis* (McGinnes & Arnold 1939), *Pisum sativum* (Briggs & Shantz 1913)
Texas doveweed: mean of *Brassica napus* (Briggs & Shantz 1913), *Chenopodium album* (Shantz & Piemeisel 1927), *Fagopyrum fagopyrum* (Briggs & Shantz 1913),

Appendix Table E.14 Growth rate control factor values for plant species included in the Victoria County EDYS model.

| Common Name | Max growth rate | Max biomass | Max plant height | Max old biomass drought loss |
|---|---|---|---|---|
| Huisache | 1.20 | 5000 | 6000 | 0.20 |
| Pecan | 0.98 | 28000 | 42672 | 0.10 |
| Hackberry | 1.10 | 14000 | 9144 | 0.10 |
| Mesquite | 1.00 | 6400 | 9144 | 0.05 |
| Post oak | 0.25 | 15000 | 9144 | 0.10 |
| Live oak | 0.40 | 29000 | 9144 | 0.10 |
| Blackbrush | 0.28 | 2400 | 1500 | 0.35 |
| Baccharis | 1.00 | 2800 | 1500 | 0.40 |
| Sea oxeye | 0.30 | 390 | 792 | 0.50 |
| Granjeno | 0.90 | 2500 | 792 | 0.50 |
| McCartney rose | 0.68 | 2000 | 792 | 0.30 |
| Rattlepod | 1.30 | 1400 | 792 | 0.70 |
| Greenbriar | 0.40 | 800 | 792 | 0.40 |
| Mustang grape | 1.00 | 2000 | 1500 | 0.40 |
| Prickly pear | 0.05 | 2400 | 792 | 0.10 |
| Big bluestem | 3.00 | 800 | 792 | 0.80 |
| Bushy bluestem | 2.25 | 390 | 792 | 0.80 |
| Purple threeawn | 2.75 | 300 | 792 | 0.20 |
| Arrowfeather threeawn | 2.50 | 390 | 792 | 0.80 |
| Silver bluestem | 2.75 | 600 | 610 | 0.40 |
| Sideoats grama | 2.75 | 600 | 610 | 0.25 |
| Buffalograss | 1.90 | 350 | 610 | 0.30 |
| Sandbur | 2.20 | 1020 | 610 | 0.80 |
| Hooded windmillgrass | 1.75 | 250 | 610 | 0.80 |
| Bermudagrass | 2.50 | 600 | 396 | 0.25 |
| Saltgrass | 1.50 | 1020 | 351 | 0.40 |
| Virginia wildrye | 2.75 | 600 | 351 | 0.40 |
| Pan-American balsamscale | 2.00 | 390 | 792 | 0.80 |
| Plains lovegrass | 2.50 | 400 | 351 | 0.20 |
| Switchgrass | 2.75 | 800 | 351 | 0.30 |
| Longtom | 2.75 | 500 | 610 | 0.40 |
| Brownseed paspalum | 2.40 | 780 | 990 | 0.40 |
| Thin paspalum | 2.25 | 400 | 610 | 0.40 |
| Common reed | 3.26 | 2100 | 850 | 0.15 |

Appendix Table E.14 (Cont.)

| Common Name | Max growth rate | Max biomass | Max plant height | Max old biomass drought loss |
|---|---|---|---|---|
| Little bluestem | 3.00 | 600 | 914 | 0.30 |
| Knotroot bristelgrass | 2.00 | 250 | 850 | 0.30 |
| Plains bristlegrass | 1.75 | 1080 | 850 | 0.30 |
| Indiangrass | 2.75 | 750 | 792 | 0.30 |
| Milo | 4.00 | 1000 | 1200 | 0.30 |
| Johnsongrass | 2.50 | 800 | 850 | 0.35 |
| Gulf cordgrass | 1.60 | 1080 | 2012 | 0.30 |
| Tall dropseed | 2.75 | 600 | 850 | 0.30 |
| Smutgrass | 2.00 | 1080 | 850 | 0.30 |
| Texas wintergrass | 2.00 | 300 | 1200 | 0.25 |
| Littletooth sedge | 1.25 | 250 | 1325 | 0.50 |
| Flatsedge | 1.50 | 500 | 351 | 0.30 |
| Olney bulrush | 2.18 | 1200 | 351 | 0.50 |
| Cattail | 1.00 | 800 | 351 | 0.50 |
| Spiny aster | 3.50 | 1000 | 1325 | 0.30 |
| Ragweed | 3.12 | 600 | 1035 | 0.20 |
| Wild indigo | 1.75 | 710 | 351 | 0.50 |
| Old-mans beard | 1.30 | 400 | 1400 | 0.35 |
| Bundleflower | 2.00 | 80 | 1035 | 0.20 |
| Mistflower | 1.75 | 300 | 1050 | 0.20 |
| Camphorweed | 3.50 | 1000 | 1325 | 0.30 |
| Frogfruit | 2.40 | 60 | 1035 | 0.10 |
| Snoutbean | 2.00 | 80 | 1050 | 0.80 |
| Ruellia | 2.00 | 50 | 1050 | 0.80 |
| Glasswort | 1.80 | 450 | 1050 | 0.40 |
| Bush sunflower | 1.75 | 300 | 1050 | 0.20 |
| Orange zexmenia | 1.35 | 200 | 1050 | 0.15 |
| Giant ragweed | 4.00 | 1000 | 1035 | 0.10 |
| Partridge pea | 1.50 | 200 | 1325 | 0.70 |
| Woolly doveweed | 1.50 | 250 | 895 | 0.80 |
| Broomweed | 3.00 | 300 | 1035 | 0.10 |
| Sunflower | 3.00 | 750 | 895 | 0.30 |
| Sumpweed | 3.50 | 1000 | 1325 | 0.30 |

Appendix Table E.15 Monthly growth rates (proportion of maximum potential growth rate, Appendix Table E.14) for plant species in the Victoria County EDYS model.

| Common Name | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0.10 | 0.30 | 0.70 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.10 |
| Pecan | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 | 0.00 |
| Hackberry | 0.00 | 0.00 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 | 0.00 |
| Mesquite | 0.00 | 0.10 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.05 |
| Post oak | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.30 | 0.10 | 0.00 |
| Live oak | 0.30 | 0.40 | 0.80 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.30 |
| Blackbrush | 0.05 | 0.15 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 |
| Baccharis | 0.00 | 0.20 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 |
| Sea oxeye | 0.00 | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.00 | 0.00 |
| Granjeno | 0.00 | 0.05 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.00 | 0.00 |
| McCartney rose | 0.00 | 0.05 | 0.30 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.10 | 0.00 |
| Rattlepod | 0.05 | 0.20 | 0.40 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.40 | 0.05 |
| Greenbriar | 0.00 | 0.20 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.40 | 0.00 |
| Mustang grape | 0.00 | 0.20 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.00 |
| Prickly pear | 0.10 | 0.10 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 |
| Big bluestem | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.30 | 0.05 |
| Bushy bluestem | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Purple threeawn | 0.10 | 0.20 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 0.60 | 0.20 | 0.10 |
| Arrowfeather threeawn | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Silver bluestem | 0.10 | 0.15 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.10 |
| Sideoats grama | 0.10 | 0.15 | 0.60 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.30 | 0.20 | 0.10 |
| Buffalograss | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 |
| Sandbur | 0.00 | 0.00 | 0.20 | 0.50 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.60 | 0.30 | 0.00 |
| Hooded windmillgrass | 0.00 | 0.01 | 0.40 | 0.80 | 0.90 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.20 | 0.00 |
| Bermudagrass | 0.00 | 0.05 | 0.20 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.20 | 0.00 |
| Saltgrass | 0.00 | 0.10 | 0.60 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Virginia wildrye | 0.50 | 0.80 | 1.00 | 1.00 | 0.80 | 0.40 | 0.10 | 0.10 | 0.30 | 0.40 | 0.50 | 0.50 |
| Pan-American balsamscale | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Plains lovegrass | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Switchgrass | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.30 | 0.10 |
| Longtom | 0.10 | 0.30 | 0.75 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.40 | 0.20 | 0.10 |
| Brownseed paspalum | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.20 | 0.00 |
| Thin paspalum | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Common reed | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 |

Appendix Table E.15 (Cont.)

| Common Name | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.10 | 0.05 |
| Knotroot bristelgrass | 0.10 | 0.30 | 0.60 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Plains bristlegrass | 0.00 | 0.10 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.00 |
| Indiangrass | 0.05 | 0.10 | 0.40 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Milo | 0.00 | 0.10 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.00 | 0.00 |
| Johnsongrass | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Gulf cordgrass | 0.10 | 0.30 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Tall dropseed | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.40 | 0.20 | 0.10 |
| Smutgrass | 0.10 | 0.30 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Texas wintergrass | 0.70 | 0.80 | 1.00 | 1.00 | 0.70 | 0.40 | 0.10 | 0.00 | 0.20 | 0.40 | 0.60 | 0.70 |
| Littletooth sedge | 0.10 | 0.25 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 |
| Flatsedge | 0.10 | 0.20 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.30 | 0.20 | 0.10 |
| Olney bulrush | 0.10 | 0.20 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.20 |
| Cattail | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Spiny aster | 0.00 | 0.15 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.15 | 0.05 |
| Ragweed | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.30 | 0.10 | 0.10 |
| Wild indigo | 0.00 | 0.10 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.20 | 0.10 | 0.00 |
| Old-mans beard | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.20 |
| Bundleflower | 0.10 | 0.20 | 0.50 | 0.70 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Mistflower | 0.00 | 0.10 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Camphorweed | 0.00 | 0.00 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 | 0.00 |
| Frogfruit | 0.10 | 0.20 | 0.50 | 0.70 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Snoutbean | 0.10 | 0.15 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Ruellia | 0.10 | 0.20 | 0.70 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Glasswort | 0.00 | 0.00 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.00 |
| Bush sunflower | 0.00 | 0.10 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Orange zexmenia | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Giant ragweed | 0.10 | 0.20 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.00 |
| Partridge pea | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 | 0.00 |
| Woolly doveweed | 0.10 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.90 | 0.80 | 0.60 | 0.40 | 0.10 | 0.00 |
| Broomweed | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 | 0.00 |
| Sunflower | 0.00 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.40 | 0.20 | 0.00 |
| Sumpweed | 0.00 | 0.00 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 | 0.00 |

Appendix Table E.16 Plant part productivity rates (proportion of maximum photosynthetic rate) for plant species in the Victoria County EDYS model.

| Common Name | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0.10 | 0.30 | 0.70 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.10 |
| Pecan | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 | 0.00 |
| Hackberry | 0.00 | 0.00 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 | 0.00 |
| Mesquite | 0.00 | 0.10 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.05 |
| Post oak | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.30 | 0.10 | 0.00 |
| Live oak | 0.30 | 0.40 | 0.80 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.30 |
| Blackbrush | 0.05 | 0.15 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 |
| Baccharis | 0.00 | 0.20 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 |
| Sea oxeye | 0.00 | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.00 | 0.00 |
| Granjeno | 0.00 | 0.05 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.00 | 0.00 |
| McCartney rose | 0.00 | 0.05 | 0.30 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.10 | 0.00 |
| Rattlepod | 0.05 | 0.20 | 0.40 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.40 | 0.05 |
| Greenbriar | 0.00 | 0.20 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.40 | 0.00 |
| Mustang grape | 0.00 | 0.20 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.00 |
| Prickly pear | 0.10 | 0.10 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 |
| Big bluestem | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.30 | 0.05 |
| Bushy bluestem | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Purple threeawn | 0.10 | 0.20 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 0.60 | 0.20 | 0.10 |
| Arrowfeather threeawn | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Silver bluestem | 0.10 | 0.15 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.10 |
| Sideoats grama | 0.10 | 0.15 | 0.60 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.30 | 0.20 | 0.10 |
| Buffalograss | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 |
| Sandbur | 0.00 | 0.00 | 0.20 | 0.50 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.60 | 0.30 | 0.00 |
| Hooded windmillgrass | 0.00 | 0.01 | 0.40 | 0.80 | 0.90 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.20 | 0.00 |
| Bermudagrass | 0.00 | 0.05 | 0.20 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.20 | 0.00 |
| Saltgrass | 0.00 | 0.10 | 0.60 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Virginia wildrye | 0.50 | 0.80 | 1.00 | 1.00 | 0.80 | 0.40 | 0.10 | 0.10 | 0.30 | 0.40 | 0.50 | 0.50 |
| Pan-American balsamscale | 0.00 | 0.00 | 0.30 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.75 | 0.40 | 0.05 | 0.00 |
| Plains lovegrass | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Switchgrass | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.30 | 0.10 |
| Longtom | 0.10 | 0.30 | 0.75 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.40 | 0.20 | 0.10 |
| Brownseed paspalum | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.20 | 0.00 |
| Thin paspalum | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Common reed | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 | 0.10 |

Appendix Table E.16 (Cont.)

| Common Name | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.05 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.10 | 0.05 |
| Knotroot bristelgrass | 0.10 | 0.30 | 0.60 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Plains bristlegrass | 0.00 | 0.10 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.00 |
| Indiangrass | 0.05 | 0.10 | 0.40 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Milo | 0.00 | 0.10 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.00 | 0.00 |
| Johnsongrass | 0.00 | 0.00 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.05 |
| Gulf cordgrass | 0.10 | 0.30 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Tall dropseed | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.40 | 0.20 | 0.10 |
| Smutgrass | 0.10 | 0.30 | 0.80 | 1.00 | 1.00 | 0.90 | 0.80 | 0.70 | 0.80 | 0.40 | 0.20 | 0.10 |
| Texas wintergrass | 0.70 | 0.80 | 1.00 | 1.00 | 0.70 | 0.40 | 0.10 | 0.00 | 0.20 | 0.40 | 0.60 | 0.70 |
| Littletooth sedge | 0.10 | 0.25 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 |
| Flatsedge | 0.10 | 0.20 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.30 | 0.20 | 0.10 |
| Olney bulrush | 0.10 | 0.20 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.20 |
| Cattail | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Spiny aster | 0.00 | 0.15 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.15 | 0.05 |
| Ragweed | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.90 | 0.50 | 0.30 | 0.10 | 0.10 |
| Wild indigo | 0.00 | 0.10 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.20 | 0.10 | 0.00 |
| Old-mans beard | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.20 |
| Bundleflower | 0.10 | 0.20 | 0.50 | 0.70 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Mistflower | 0.00 | 0.10 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Camphorweed | 0.00 | 0.00 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 | 0.00 |
| Frogfruit | 0.10 | 0.20 | 0.50 | 0.70 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.10 |
| Snoutbean | 0.10 | 0.15 | 0.60 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Ruellia | 0.10 | 0.20 | 0.70 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.40 | 0.20 | 0.10 |
| Glasswort | 0.00 | 0.00 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.50 | 0.20 | 0.00 |
| Bush sunflower | 0.00 | 0.10 | 0.40 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Orange zexmenia | 0.00 | 0.10 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.30 | 0.00 | 0.00 |
| Giant ragweed | 0.10 | 0.20 | 0.50 | 0.90 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 | 0.00 |
| Partridge pea | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 | 0.00 |
| Woolly doveweed | 0.10 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.90 | 0.80 | 0.60 | 0.40 | 0.10 | 0.00 |
| Broomweed | 0.10 | 0.20 | 0.40 | 0.80 | 1.00 | 1.00 | 0.90 | 0.70 | 0.50 | 0.30 | 0.10 | 0.00 |
| Sunflower | 0.00 | 0.10 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.40 | 0.20 | 0.00 |
| Sumpweed | 0.00 | 0.00 | 0.30 | 0.60 | 1.00 | 1.00 | 1.00 | 0.80 | 0.60 | 0.30 | 0.10 | 0.00 |

Appendix Table E.17 Green-out plant part productivity conversion rates (proportion of biomass weight converted to new production at green-out) for plant species in the Victoria County EDYS model.

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.02 | 0.00 | 0.01 | 0.05 | 1.00 | 0.00 |
| Pecan | 0.02 | 0.00 | 0.01 | 0.02 | 1.00 | 0.00 |
| Hackberry | 0.01 | 0.00 | 0.01 | 0.03 | 1.00 | 0.00 |
| Mesquite | 0.02 | 0.00 | 0.01 | 0.05 | 1.00 | 0.00 |
| Post oak | 0.01 | 0.00 | 0.01 | 0.02 | 1.00 | 0.00 |
| Live oak | 0.01 | 0.00 | 0.01 | 0.02 | 1.00 | 0.00 |
| Blackbrush | 0.02 | 0.00 | 0.02 | 0.05 | 1.00 | 0.00 |
| Baccharis | 0.04 | 0.00 | 0.04 | 0.10 | 1.00 | 0.00 |
| Sea oxeye | 0.10 | 0.00 | 0.00 | 0.10 | 0.80 | 0.00 |
| Granjeno | 0.02 | 0.00 | 0.02 | 0.05 | 1.00 | 0.00 |
| McCartney rose | 0.01 | 0.00 | 0.00 | 0.05 | 1.00 | 0.00 |
| Rattlepod | 0.02 | 0.00 | 0.05 | 0.10 | 1.00 | 0.00 |
| Greenbriar | 0.10 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Mustang grape | 0.01 | 0.00 | 0.02 | 0.10 | 1.00 | 0.00 |
| Prickly pear | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Big bluestem | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Bushy bluestem | 0.00 | 0.00 | 0.15 | 0.50 | 1.00 | 0.00 |
| Purple threeawn | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Arrowfeather threeawn | 0.00 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Silver bluestem | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Sideoats grama | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Buffalograss | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Sandbur | 0.10 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Hooded windmillgrass | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Bermudagrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Saltgrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Virginia wildrye | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Pan-American balsamscale | 0.00 | 0.00 | 0.15 | 0.50 | 1.00 | 0.00 |
| Plains lovegrass | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Switchgrass | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Longtom | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Brownseed paspalum | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Thin paspalum | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Common reed | 0.10 | 0.00 | 0.10 | 0.25 | 1.00 | 0.00 |

Appendix Table E.17 (Cont.)

| Common Name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Knotroot bristelgrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Plains bristlegrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Indiangrass | 0.05 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Milo | 0.00 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Johnsongrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Gulf cordgrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Tall dropseed | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Smutgrass | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Texas wintergrass | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Littletooth sedge | 0.05 | 0.00 | 0.05 | 0.50 | 1.00 | 0.00 |
| Flatsedge | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Olney bulrush | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Cattail | 0.30 | 0.00 | 0.20 | 0.30 | 1.00 | 0.00 |
| Spiny aster | 0.00 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Ragweed | 0.10 | 0.00 | 0.10 | 0.40 | 1.00 | 0.00 |
| Wild indigo | 0.10 | 0.00 | 0.10 | 1.00 | 0.00 | 0.00 |
| Old-mans beard | 0.10 | 0.00 | 0.10 | 0.40 | 1.00 | 0.00 |
| Bundleflower | 0.05 | 0.00 | 0.10 | 0.40 | 1.00 | 0.00 |
| Mistflower | 0.10 | 0.00 | 0.20 | 0.40 | 1.00 | 0.00 |
| Camphorweed | 0.00 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Frogfruit | 0.05 | 0.00 | 0.10 | 0.30 | 1.00 | 0.00 |
| Snoutbean | 0.10 | 0.00 | 0.20 | 0.30 | 1.00 | 0.00 |
| Ruellia | 0.10 | 0.00 | 0.10 | 0.30 | 1.00 | 0.00 |
| Glasswort | 0.10 | 0.00 | 0.10 | 0.50 | 1.00 | 0.00 |
| Bush sunflower | 0.05 | 0.00 | 0.20 | 0.20 | 1.00 | 0.00 |
| Orange zexmenia | 0.10 | 0.00 | 0.10 | 0.40 | 1.00 | 0.00 |
| Giant ragweed | 0.00 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Partridge pea | 0.00 | 0.00 | 0.20 | 0.40 | 1.00 | 0.00 |
| Woolly doveweed | 0.00 | 0.00 | 0.10 | 0.20 | 1.00 | 0.00 |
| Broomweed | 0.00 | 0.00 | 0.10 | 0.20 | 1.00 | 0.00 |
| Sunflower | 0.00 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |
| Sumpweed | 0.00 | 0.00 | 0.20 | 0.50 | 1.00 | 0.00 |

Appendix Table E.18 Physiological control constants for plant species in the Victoria County EDYS model.

| Common Name | Growing season max root:shoot | Growing season green-out shoot:root | Max 1-mo seed germination | Max 1st-mo seedling growth |
|---|---|---|---|---|
| Huisache | 1.700 | 0.230 | 0.730 | 20 |
| Pecan | 1.500 | 0.670 | 0.730 | 5 |
| Hackberry | 0.560 | 1.780 | 0.800 | 10 |
| Mesquite | 0.640 | 1.560 | 0.500 | 10 |
| Post oak | 0.720 | 0.130 | 0.950 | 8 |
| Live oak | 0.920 | 1.090 | 0.630 | 8 |
| Blackbrush | 1.300 | 0.200 | 0.960 | 20 |
| Baccharis | 1.220 | 0.820 | 0.940 | 10 |
| Sea oxeye | 1.800 | 0.280 | 0.750 | 15 |
| Granjeno | 1.320 | 0.200 | 0.750 | 15 |
| McCartney rose | 5.100 | 0.097 | 0.480 | 20 |
| Rattlepod | 1.220 | 0.190 | 0.260 | 30 |
| Greenbriar | 2.000 | 0.250 | 0.600 | 30 |
| Mustang grape | 1.000 | 1.000 | 0.640 | 10 |
| Prickly pear | 0.620 | 1.610 | 0.700 | 10 |
| Big bluestem | 1.720 | 0.230 | 0.540 | 20 |
| Bushy bluestem | 1.300 | 0.750 | 0.540 | 20 |
| Purple threeawn | 3.780 | 0.260 | 0.160 | 20 |
| Arrowfeather threeawn | 1.300 | 0.750 | 0.540 | 20 |
| Silver bluestem | 2.000 | 0.250 | 0.900 | 30 |
| Sideoats grama | 3.200 | 0.310 | 0.720 | 20 |
| Buffalograss | 2.400 | 0.270 | 0.618 | 30 |
| Sandbur | 2.000 | 0.249 | 0.440 | 15 |
| Hooded windmillgrass | 1.800 | 0.240 | 0.440 | 15 |
| Bermudagrass | 2.420 | 0.410 | 0.850 | 20 |
| Saltgrass | 1.400 | 0.530 | 0.900 | 30 |
| Virginia wildrye | 1.680 | 0.230 | 0.900 | 30 |
| Pan-American balsamscale | 1.300 | 0.750 | 0.540 | 20 |
| Plains lovegrass | 1.160 | 0.860 | 0.800 | 20 |
| Switchgrass | 1.960 | 0.510 | 0.480 | 20 |
| Longtom | 5.000 | 0.360 | 0.530 | 30 |
| Brownseed paspalum | 2.400 | 0.210 | 0.530 | 30 |
| Thin paspalum | 1.520 | 0.220 | 0.530 | 30 |
| Common reed | 0.720 | 1.250 | 0.010 | 10 |

Appendix Table E.18 (Cont.)

| Common Name | Growing season max root:shoot | Growing season green-out shoot:root | Max 1-mo seed germination | Max 1st-mo seedling growth |
|---|---|---|---|---|
| Little bluestem | 3.260 | 0.310 | 0.480 | 20 |
| Knotroot bristelgrass | 2.200 | 0.260 | 0.580 | 25 |
| Plains bristlegrass | 3.400 | 0.220 | 0.580 | 25 |
| Indiangrass | 1.720 | 0.580 | 0.630 | 20 |
| Milo | 2.000 | 0.250 | 0.580 | 25 |
| Johnsongrass | 4.420 | 0.230 | 0.880 | 20 |
| Gulf cordgrass | 3.400 | 0.220 | 0.580 | 25 |
| Tall dropseed | 2.200 | 0.450 | 0.800 | 20 |
| Smutgrass | 3.400 | 0.220 | 0.580 | 25 |
| Texas wintergrass | 2.520 | 0.400 | 0.130 | 20 |
| Littletooth sedge | 2.400 | 0.270 | 0.353 | 30 |
| Flatsedge | 6.660 | 0.170 | 0.460 | 20 |
| Olney bulrush | 1.800 | 0.420 | 0.250 | 20 |
| Cattail | 6.660 | 0.170 | 0.650 | 20 |
| Spiny aster | 2.300 | 0.350 | 0.950 | 40 |
| Ragweed | 2.520 | 0.400 | 0.600 | 20 |
| Wild indigo | 1.600 | 0.300 | 0.520 | 15 |
| Old-mans beard | 2.600 | 0.280 | 0.960 | 20 |
| Bundleflower | 2.920 | 0.350 | 0.420 | 20 |
| Mistflower | 2.520 | 0.400 | 0.380 | 20 |
| Camphorweed | 2.300 | 0.350 | 0.950 | 40 |
| Frogfruit | 1.000 | 0.170 | 0.500 | 20 |
| Snoutbean | 1.400 | 0.210 | 0.700 | 50 |
| Ruellia | 1.200 | 0.190 | 0.700 | 50 |
| Glasswort | 3.900 | 0.129 | 0.990 | 30 |
| Bush sunflower | 2.520 | 0.400 | 0.380 | 20 |
| Orange zexmenia | 2.520 | 0.400 | 0.500 | 20 |
| Giant ragweed | 1.000 | 0.170 | 0.500 | 20 |
| Partridge pea | 1.200 | 0.190 | 0.260 | 30 |
| Woolly doveweed | 0.800 | 0.140 | 0.700 | 50 |
| Broomweed | 1.200 | 0.190 | 0.500 | 20 |
| Sunflower | 0.340 | 2.940 | 0.820 | 30 |
| Sumpweed | 2.300 | 0.350 | 0.950 | 40 |

Growing season max root:shoot ratio = twice the initial root:shoot ratio value (Appendix Table E.2). Examples of field root:shoot ratios include: *Quercus robur* 0.35 (Rodin & Bazilevich 1967); *Q. velutina* 0.54 (Nadelhoffer et al. 1985); *Larrea tridentata* 0.42 (Chew & Chew 1965), 1.08 (Wallace et al. 1974); *Bouteloua gracilis* 2.39 (Samuel & Hart 1992), 4.10 (Coupland & Johnson 1965), 6.90 (Vinton & Burke 1995); *Cynodon dactylon* 0.62 (Rodriguez et al. 2002), 1.60 (Hons et al. 1979), 2.90 (Beaty et al. 1975); *Distichlis spicata* 1.10 (Seliskar & Gallagher 2000); *Hilaria jamesii* 5.31 (Moore & West 1973); *Hilaria rigida* 0.57 (Robberecht et al. 1983); *Oryzopsis hymenoides* 2.62 (Orodho & Trlica 1990); *Paspalum notatum* 2.27 (Fiala et al. 1991), 2.50 (Beaty et al. 1975); *Schizachyrium scoparium* 2.76 (Cerligione et al. 1987); tallgrass prairie 0.90 Oklahoma (Sims & Singh 1978), 0.97 Missouri (Buyanovsky et al. 1987); Kansas midgrass prairie 1.76 (Sims & Singh 1978); shortgrass plains 1.87 Colorado (Sims & Singh 1978), 2.21 Texas (Sims & Singh 1978); *Carex nebrascensis* 5.62 (Manning et al. 1989); *Juncus roemerianus* 1.55 (Gallagher et al. 1977).

Growing season green-out shoot:root ratio = half the inverse of initial shoot:root ratio (Appendix Table E.2).

Appendix Table E.19 End of growing season dieback (proportion of tissue lost at onset of dormancy) for plant species in the Victoria County EDYS model.

| Species | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Huisache | 0.02 | 0.06 | 0.01 | 0.02 | 0.82 | 1.00 |
| Pecan | 0.01 | 0.05 | 0.01 | 0.01 | 1.00 | 1.00 |
| Hackberry | 0.01 | 0.05 | 0.01 | 0.02 | 0.98 | 1.00 |
| Mesquite | 0.01 | 0.05 | 0.01 | 0.02 | 0.90 | 1.00 |
| Post oak | 0.01 | 0.05 | 0.01 | 0.02 | 1.00 | 1.00 |
| Live oak | 0.01 | 0.05 | 0.01 | 0.01 | 0.74 | 1.00 |
| Blackbrush | 0.03 | 0.15 | 0.02 | 0.10 | 0.40 | 1.00 |
| Baccharis | 0.04 | 0.15 | 0.05 | 0.15 | 0.85 | 1.00 |
| Sea oxeye | 0.01 | 0.05 | 0.01 | 0.07 | 1.00 | 1.00 |
| Granjeno | 0.03 | 0.15 | 0.02 | 0.05 | 0.80 | 1.00 |
| McCartney rose | 0.03 | 0.10 | 0.02 | 0.19 | 0.60 | 1.00 |
| Rattlepod | 0.08 | 0.15 | 0.10 | 0.20 | 0.95 | 1.00 |
| Greenbriar | 0.08 | 0.20 | 0.10 | 0.40 | 1.00 | 1.00 |
| Mustang grape | 0.04 | 0.15 | 0.01 | 0.08 | 0.95 | 1.00 |
| Prickly pear | 0.04 | 0.10 | 0.02 | 0.08 | 0.05 | 1.00 |
| Big bluestem | 0.03 | 0.15 | 0.02 | 0.70 | 0.95 | 1.00 |
| Bushy bluestem | 0.06 | 0.15 | 0.10 | 0.80 | 1.00 | 1.00 |
| Purple threeawn | 0.10 | 0.20 | 0.05 | 0.95 | 0.95 | 1.00 |
| Arrowfeather threeawn | 0.08 | 0.15 | 0.05 | 1.00 | 1.00 | 1.00 |
| Silver bluestem | 0.07 | 0.15 | 0.03 | 0.80 | 0.95 | 1.00 |
| Sideoats grama | 0.05 | 0.15 | 0.03 | 0.90 | 0.95 | 1.00 |
| Buffalograss | 0.15 | 0.30 | 0.15 | 0.85 | 0.90 | 1.00 |
| Sandbur | 0.10 | 0.20 | 0.05 | 1.00 | 1.00 | 1.00 |
| Hooded windmillgrass | 0.15 | 0.30 | 0.08 | 0.95 | 0.95 | 1.00 |
| Bermudagrass | 0.10 | 0.20 | 0.15 | 0.70 | 0.90 | 1.00 |
| Saltgrass | 0.10 | 0.20 | 0.05 | 0.95 | 1.00 | 1.00 |
| Virginia wildrye | 0.12 | 0.15 | 0.10 | 0.95 | 0.99 | 1.00 |
| Pan-American balsamscale | 0.05 | 0.15 | 0.05 | 0.90 | 0.95 | 1.00 |
| Plains lovegrass | 0.10 | 0.20 | 0.05 | 0.90 | 0.95 | 1.00 |
| Switchgrass | 0.05 | 0.15 | 0.02 | 0.80 | 0.95 | 1.00 |
| Longtom | 0.15 | 0.30 | 0.06 | 0.80 | 0.95 | 1.00 |
| Brownseed paspalum | 0.10 | 0.20 | 0.05 | 0.90 | 1.00 | 1.00 |
| Thin paspalum | 0.17 | 0.25 | 0.12 | 0.95 | 0.99 | 1.00 |
| Common reed | 0.03 | 0.10 | 0.05 | 0.80 | 0.90 | 1.00 |

Appendix Table E.19 (Cont.)

| Species | CRoot | FRoot | Trunk | Stems | Leaves | Seeds |
|---|---|---|---|---|---|---|
| Little bluestem | 0.10 | 0.20 | 0.03 | 0.80 | 0.95 | 1.00 |
| Knotroot bristelgrass | 0.15 | 0.30 | 0.13 | 0.90 | 0.90 | 1.00 |
| Plains bristlegrass | 0.08 | 0.20 | 0.04 | 0.95 | 0.90 | 1.00 |
| Indiangrass | 0.05 | 0.15 | 0.02 | 0.80 | 0.95 | 1.00 |
| Milo | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Johnsongrass | 0.10 | 0.20 | 0.10 | 0.90 | 0.95 | 1.00 |
| Gulf cordgrass | 0.08 | 0.20 | 0.04 | 0.95 | 0.90 | 1.00 |
| Tall dropseed | 0.10 | 0.20 | 0.05 | 0.95 | 0.97 | 1.00 |
| Smutgrass | 0.08 | 0.20 | 0.04 | 0.85 | 0.90 | 1.00 |
| Texas wintergrass | 0.15 | 0.30 | 0.15 | 0.95 | 0.95 | 1.00 |
| Littletooth sedge | 0.15 | 0.30 | 0.20 | 0.90 | 0.95 | 1.00 |
| Flatsedge | 0.15 | 0.30 | 0.15 | 0.97 | 0.95 | 1.00 |
| Olney bulrush | 0.08 | 0.20 | 0.05 | 0.95 | 1.00 | 1.00 |
| Cattail | 0.10 | 0.20 | 0.05 | 0.95 | 0.90 | 1.00 |
| Spiny aster | 0.08 | 0.20 | 0.10 | 0.90 | 1.00 | 1.00 |
| Ragweed | 0.18 | 0.35 | 0.20 | 0.95 | 0.99 | 1.00 |
| Wild indigo | 0.10 | 0.20 | 0.05 | 0.95 | 1.00 | 1.00 |
| Old-mans beard | 0.15 | 0.30 | 0.12 | 0.60 | 0.90 | 1.00 |
| Bundleflower | 0.10 | 0.20 | 0.12 | 0.60 | 0.95 | 1.00 |
| Mistflower | 0.10 | 0.20 | 0.20 | 0.95 | 0.99 | 1.00 |
| Camphorweed | 0.08 | 0.20 | 0.10 | 1.00 | 1.00 | 1.00 |
| Frogfruit | 0.20 | 0.30 | 0.20 | 0.80 | 0.95 | 1.00 |
| Snoutbean | 0.05 | 0.15 | 0.05 | 0.40 | 0.95 | 1.00 |
| Ruellia | 0.18 | 0.30 | 0.10 | 0.60 | 0.80 | 1.00 |
| Glasswort | 0.20 | 0.40 | 0.20 | 1.00 | 1.00 | 1.00 |
| Bush sunflower | 0.10 | 0.20 | 0.20 | 0.95 | 0.99 | 1.00 |
| Orange zexmenia | 0.10 | 0.20 | 0.20 | 0.95 | 0.98 | 1.00 |
| Giant ragweed | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Partridge pea | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Woolly doveweed | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Broomweed | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Sunflower | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Sumpweed | 0.08 | 0.20 | 0.10 | 1.00 | 1.00 | 1.00 |

**Data Sources**

Weaver & Zink (1946); Caldwell & Camp (1974); Peet et al. (2005).

Appendix Table E.20 Shading effect on species included in the Victoria County EDYS model. Values are the proportional decreases in maximum potential production of the **shaded species** resulting from 100% cover of the **shading species.**

| Common Name | Huisache | Pecan | Hackberry | Mesquite | Post oak | Live oak | Blackbrush | Baccharis | Sea oxeye |
|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.025 | 0.010 | 0.005 | 0.010 | 0.025 | 0.000 | 0.005 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.060 | 0.010 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.015 | 0.005 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.010 | 0.020 | 0.015 | 0.010 | 0.020 | 0.040 | 0.000 | 0.005 | 0.000 |
| Baccharis | 0.000 | 0.030 | 0.020 | 0.020 | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.005 | 0.010 | 0.005 | 0.005 | 0.010 | 0.015 | 0.000 | 0.005 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.000 | 0.005 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.040 | 0.020 | 0.010 | 0.000 | 0.040 | 0.000 | 0.010 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Common reed | 0.000 | 0.020 | 0.010 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Huisache | Pecan | Hackberry | Mesquite | Post oak | Live oak | Blackbrush | Baccharis | Sea oxeye |
|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bundleflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Snoutbean | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ruellia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Broomweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Granjeno | McCartney rose | Rattlepod | Greenbriar | Mustang grape | Prickly pear | Big bluestem | Bushy bluestem | Purple threeawn |
|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.005 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 | 0.040 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.005 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.050 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.010 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.010 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.010 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Granjeno | McCartney rose | Rattlepod | Greenbriar | Mustang grape | Prickly pear | Big bluestem | Bushy bluestem | Purple threeawn |
|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.090 | 0.000 | 0.010 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.060 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.020 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 |
| Bundleflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.090 | 0.000 | 0.010 |
| Snoutbean | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.090 | 0.000 | 0.000 |
| Ruellia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.090 | 0.000 | 0.000 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.010 |
| Broomweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.010 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Arrowfeather threeawn | Silver bluestem | Sideoats grama | Buffalograss | Sandbur | Hooded windmillgrass | Bermudagrass |
|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.020 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.030 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bermudagrass | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.010 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.010 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Arrowfeather threeawn | Silver bluestem | Sideoats grama | Buffalograss | Sandbur | Hooded windmillgrass | Bermudagrass |
|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.040 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.090 | 0.080 | 0.000 | 0.000 | 0.000 | 0.000 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.040 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.010 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bundleflower | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.020 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 |
| Snoutbean | 0.000 | 0.010 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ruellia | 0.000 | 0.020 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.050 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 |
| Broomweed | 0.000 | 0.060 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Saltgrass | Virginia wildrye | Pan-American balsamscale | Plains lovegrass | Switchgrass | Longtom | Brownseed paspalum | Thin paspalum |
|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.010 | 0.000 | 0.000 | 0.080 | 0.000 | 0.000 | 0.020 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.020 | 0.000 | 0.000 | 0.080 | 0.000 | 0.000 | 0.020 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.010 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.010 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Saltgrass | Virginia wildrye | Pan-American balsamscale | Plains lovegrass | Switchgrass | Longtom | Brownseed paspalum | Thin paspalum |
|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.020 | 0.000 | 0.000 | 0.060 | 0.030 | 0.000 | 0.020 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.010 | 0.000 | 0.000 | 0.080 | 0.020 | 0.000 | 0.020 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.010 |
| Bundleflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.010 | 0.000 | 0.000 | 0.090 | 0.020 | 0.000 | 0.020 |
| Snoutbean | 0.000 | 0.010 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.020 |
| Ruellia | 0.000 | 0.010 | 0.000 | 0.000 | 0.080 | 0.000 | 0.000 | 0.010 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.010 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.040 |
| Broomweed | 0.000 | 0.010 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.040 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Common reed | Little bluestem | Knotroot bristelgrass | Plains bristlegrass | Indiangrass | Milo | Johnsongrass | Gulf cordgrass |
|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 |
| Baccharis | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.080 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.010 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.100 | 0.050 | 0.000 | 0.000 | 0.100 | 0.000 | 0.100 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.060 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.010 | 0.000 |
| Buffalograss | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 |
| Bermudagrass | 0.020 | 0.050 | 0.000 | 0.000 | 0.050 | 0.000 | 0.040 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Common reed | Little bluestem | Knotroot bristelgrass | Plains bristlegrass | Indiangrass | Milo | Johnsongrass | Gulf cordgrass |
|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 |
| Johnsongrass | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.050 | 0.010 | 0.000 | 0.000 | 0.030 | 0.000 | 0.030 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.050 | 0.010 | 0.000 | 0.000 | 0.050 | 0.000 | 0.050 | 0.000 |
| Littletooth sedge | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 |
| Flatsedge | 0.020 | 0.050 | 0.000 | 0.000 | 0.100 | 0.000 | 0.100 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.050 | 0.050 | 0.000 | 0.000 | 0.100 | 0.000 | 0.100 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 |
| Bundleflower | 0.100 | 0.070 | 0.000 | 0.000 | 0.100 | 0.000 | 0.100 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 |
| Snoutbean | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 |
| Ruellia | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.100 | 0.010 | 0.000 | 0.000 | 0.050 | 0.000 | 0.050 | 0.000 |
| Orange zexmenia | 0.100 | 0.020 | 0.000 | 0.000 | 0.050 | 0.000 | 0.050 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 |
| Broomweed | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 |
| Sunflower | 0.070 | 0.010 | 0.000 | 0.000 | 0.050 | 0.000 | 0.050 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Tall dropseed | Smutgrass | Texas wintergrass | Littletooth sedge | Flatsedge | Olney bulrush | Cattail | Spiny aster | Ragweed |
|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 | 0.000 |
| Buffalograss | 0.020 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.030 | 0.000 | 0.030 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.020 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.040 | 0.000 | 0.040 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.010 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.010 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.010 | 0.000 | 0.010 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.010 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.010 | 0.000 | 0.030 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Tall dropseed | Smutgrass | Texas wintergrass | Littletooth sedge | Flatsedge | Olney bulrush | Cattail | Spiny aster | Ragweed |
|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.020 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.020 | 0.000 | 0.030 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 |
| Milo | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.030 | 0.000 | 0.040 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.010 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 |
| Littletooth sedge | 0.020 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.030 | 0.000 | 0.040 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.010 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 |
| Bundleflower | 0.040 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.080 | 0.000 | 0.050 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.020 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.010 | 0.000 | 0.030 |
| Snoutbean | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 |
| Ruellia | 0.030 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.020 | 0.000 | 0.030 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 | 0.020 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.040 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.020 | 0.000 | 0.040 |
| Broomweed | 0.030 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.020 | 0.000 | 0.040 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Wild indigo | Old-mans beard | Bundleflower | Mistflower | Camphorweed | Frogfruit | Snoutbean | Ruellia |
|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Wild indigo | Old-mans beard | Bundleflower | Mistflower | Camphorweed | Frogfruit | Snoutbean | Ruellia |
|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bundleflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Snoutbean | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ruellia | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 |
| Broomweed | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Glasswort | Bush sunflower | Orange zexmenia | Giant ragweed | Partridge pea | Woolly doveweed | Broomweed | Sunflower |
|---|---|---|---|---|---|---|---|---|
| Huisache | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pecan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hackberry | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mesquite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Post oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Live oak | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Blackbrush | 0.000 | 0.000 | 0.000 | 0.700 | 0.000 | 0.000 | 0.000 | 0.000 |
| Baccharis | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea oxeye | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Granjeno | 0.000 | 0.000 | 0.000 | 0.500 | 0.000 | 0.000 | 0.000 | 0.000 |
| McCartney rose | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rattlepod | 0.000 | 0.000 | 0.000 | 0.800 | 0.000 | 0.000 | 0.000 | 0.100 |
| Greenbriar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mustang grape | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Prickly pear | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Big bluestem | 0.000 | 0.000 | 0.000 | 0.500 | 0.000 | 0.000 | 0.000 | 0.100 |
| Bushy bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Purple threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 |
| Arrowfeather threeawn | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Silver bluestem | 0.000 | 0.000 | 0.000 | 0.600 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideoats grama | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Buffalograss | 0.000 | 0.010 | 0.000 | 0.900 | 0.000 | 0.050 | 0.000 | 0.300 |
| Sandbur | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Hooded windmillgrass | 0.000 | 0.020 | 0.000 | 0.950 | 0.000 | 0.050 | 0.010 | 0.600 |
| Bermudagrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saltgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Virginia wildrye | 0.000 | 0.000 | 0.000 | 0.600 | 0.000 | 0.000 | 0.000 | 0.300 |
| Pan-American balsamscale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Plains lovegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Switchgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Longtom | 0.000 | 0.010 | 0.000 | 0.700 | 0.000 | 0.010 | 0.000 | 0.300 |
| Brownseed paspalum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thin paspalum | 0.000 | 0.030 | 0.010 | 0.800 | 0.000 | 0.040 | 0.010 | 0.600 |
| Common reed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Glasswort | Bush sunflower | Orange zexmenia | Giant ragweed | Partridge pea | Woolly doveweed | Broomweed | Sunflower |
|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Knotroot bristelgrass | 0.000 | 0.010 | 0.000 | 0.800 | 0.000 | 0.030 | 0.020 | 0.500 |
| Plains bristlegrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Indiangrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Milo | 0.000 | 0.020 | 0.000 | 0.900 | 0.000 | 0.010 | 0.000 | 0.400 |
| Johnsongrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gulf cordgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Tall dropseed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Smutgrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Texas wintergrass | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Littletooth sedge | 0.000 | 0.020 | 0.000 | 0.800 | 0.000 | 0.030 | 0.010 | 0.600 |
| Flatsedge | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Olney bulrush | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cattail | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spiny aster | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 |
| Wild indigo | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Old-mans beard | 0.000 | 0.000 | 0.000 | 0.700 | 0.000 | 0.000 | 0.000 | 0.300 |
| Bundleflower | 0.000 | 0.030 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 |
| Mistflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Camphorweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Frogfruit | 0.000 | 0.000 | 0.000 | 0.400 | 0.000 | 0.020 | 0.010 | 0.300 |
| Snoutbean | 0.000 | 0.010 | 0.000 | 0.800 | 0.000 | 0.030 | 0.010 | 0.500 |
| Ruellia | 0.000 | 0.030 | 0.000 | 0.800 | 0.000 | 0.020 | 0.010 | 0.400 |
| Glasswort | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bush sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Orange zexmenia | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 |
| Giant ragweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partridge pea | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Woolly doveweed | 0.000 | 0.020 | 0.000 | 0.900 | 0.000 | 0.000 | 0.010 | 0.500 |
| Broomweed | 0.000 | 0.040 | 0.010 | 0.800 | 0.000 | 0.020 | 0.000 | 0.500 |
| Sunflower | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sumpweed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Sumpweed |
|---|---|
| Huisache | 0.000 |
| Pecan | 0.000 |
| Hackberry | 0.000 |
| Mesquite | 0.000 |
| Post oak | 0.000 |
| Live oak | 0.000 |
| Blackbrush | 0.000 |
| Baccharis | 0.000 |
| Sea oxeye | 0.000 |
| Granjeno | 0.000 |
| McCartney rose | 0.000 |
| Rattlepod | 0.000 |
| Greenbriar | 0.000 |
| Mustang grape | 0.000 |
| Prickly pear | 0.000 |
| Big bluestem | 0.000 |
| Bushy bluestem | 0.000 |
| Purple threeawn | 0.000 |
| Arrowfeather threeawn | 0.000 |
| Silver bluestem | 0.000 |
| Sideoats grama | 0.000 |
| Buffalograss | 0.000 |
| Sandbur | 0.000 |
| Hooded windmillgrass | 0.000 |
| Bermudagrass | 0.000 |
| Saltgrass | 0.000 |
| Virginia wildrye | 0.000 |
| Pan-American balsamscale | 0.000 |
| Plains lovegrass | 0.000 |
| Switchgrass | 0.000 |
| Longtom | 0.000 |
| Brownseed paspalum | 0.000 |
| Thin paspalum | 0.000 |
| Common reed | 0.000 |

Appendix Table E.20 (Cont.)

| Common Name | Sumpweed |
|---|---|
| Little bluestem | 0.000 |
| Knotroot bristelgrass | 0.000 |
| Plains bristlegrass | 0.000 |
| Indiangrass | 0.000 |
| Milo | 0.000 |
| Johnsongrass | 0.000 |
| Gulf cordgrass | 0.000 |
| Tall dropseed | 0.000 |
| Smutgrass | 0.000 |
| Texas wintergrass | 0.000 |
| Littletooth sedge | 0.000 |
| Flatsedge | 0.000 |
| Olney bulrush | 0.000 |
| Cattail | 0.000 |
| Spiny aster | 0.000 |
| Ragweed | 0.000 |
| Wild indigo | 0.000 |
| Old-mans beard | 0.000 |
| Bundleflower | 0.000 |
| Mistflower | 0.000 |
| Camphorweed | 0.000 |
| Frogfruit | 0.000 |
| Snoutbean | 0.000 |
| Ruellia | 0.000 |
| Glasswort | 0.000 |
| Bush sunflower | 0.000 |
| Orange zexmenia | 0.000 |
| Giant ragweed | 0.000 |
| Partridge pea | 0.000 |
| Woolly doveweed | 0.000 |
| Broomweed | 0.000 |
| Sunflower | 0.000 |
| Sumpweed | 0.000 |

Appendix Table E.21 Cattle preference factors for plant parts, by species, in the Victoria County EDYS model. Values are relative rankings (1 = highest, 30 = lowest). High rankings indicate the plant part and species are highly preferred by cattle.

| Common name | Croot | Froot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 35 | 35 | 35 | 35 | 10 | 21 | 36 | 28 | 10 | 10 | 35 |
| Pecan | 20 | 19 | 22 | 16 | 11 | 19 | 19 | 13 | 8 | 7 | 19 |
| Hackberry | 20 | 19 | 22 | 15 | 10 | 15 | 19 | 11 | 6 | 5 | 17 |
| Mesquite | 20 | 19 | 22 | 17 | 14 | 3 | 19 | 15 | 8 | 7 | 17 |
| Post oak | 35 | 35 | 35 | 35 | 25 | 34 | 35 | 31 | 25 | 25 | 34 |
| Live oak | 20 | 19 | 22 | 17 | 13 | 16 | 19 | 15 | 7 | 6 | 16 |
| Blackbrush | 35 | 35 | 35 | 35 | 12 | 21 | 35 | 29 | 12 | 12 | 35 |
| Baccharis | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Sea oxeye | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Granjeno | 35 | 35 | 35 | 34 | 16 | 16 | 31 | 29 | 16 | 16 | 36 |
| McCartney rose | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Rattlepod | 35 | 35 | 35 | 34 | 26 | 36 | 35 | 30 | 25 | 25 | 36 |
| Greenbriar | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Mustang grape | 19 | 18 | 21 | 16 | 9 | 4 | 18 | 11 | 6 | 5 | 17 |
| Prickly pear | 19 | 18 | 20 | 8 | 8 | 3 | 18 | 18 | 3 | 2 | 17 |
| Big bluestem | 11 | 11 | 3 | 1 | 1 | 1 | 11 | 9 | 1 | 1 | 34 |
| Bushy bluestem | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Purple threeawn | 18 | 17 | 5 | 3 | 3 | 3 | 4 | 4 | 3 | 2 | 17 |
| Arrowfeather threeawn | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Silver bluestem | 10 | 10 | 3 | 2 | 2 | 2 | 9 | 9 | 1 | 1 | 35 |
| Sideoats grama | 18 | 17 | 4 | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 8 |
| Buffalograss | 8 | 8 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 35 |
| Sandbur | 6 | 6 | 6 | 1 | 1 | 1 | 5 | 5 | 1 | 1 | 5 |
| Hooded windmillgrass | 9 | 9 | 5 | 4 | 4 | 4 | 8 | 8 | 3 | 3 | 36 |
| Bermudagrass | 18 | 17 | 4 | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 8 |
| Saltgrass | 6 | 6 | 6 | 1 | 1 | 1 | 5 | 5 | 1 | 1 | 5 |
| Virginia wildrye | 10 | 10 | 4 | 2 | 2 | 2 | 9 | 9 | 1 | 1 | 35 |
| Pan-American balsamscale | 29 | 29 | 29 | 26 | 10 | 10 | 31 | 20 | 6 | 6 | 12 |
| Plains lovegrass | 6 | 6 | 6 | 1 | 1 | 1 | 5 | 5 | 1 | 1 | 5 |
| Switchgrass | 18 | 17 | 5 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 8 |
| Longtom | 9 | 8 | 3 | 2 | 2 | 2 | 8 | 8 | 1 | 1 | 34 |
| Brownseed paspalum | 7 | 7 | 7 | 2 | 2 | 2 | 5 | 5 | 1 | 1 | 5 |
| Thin paspalum | 10 | 10 | 4 | 3 | 3 | 3 | 9 | 9 | 2 | 2 | 35 |
| Common reed | 7 | 7 | 7 | 2 | 2 | 2 | 5 | 5 | 1 | 1 | 5 |

Appendix Table E.21 (Cont.)

| Common name | Croot | Froot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 18 | 17 | 5 | 2 | 2 | 2 | 4 | 4 | 2 | 1 | 9 |
| Knotroot bristelgrass | 10 | 10 | 6 | 4 | 4 | 4 | 9 | 9 | 3 | 3 | 35 |
| Plains bristlegrass | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Indiangrass | 18 | 17 | 5 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 3 |
| Milo | 10 | 10 | 9 | 3 | 2 | 2 | 11 | 9 | 1 | 1 | 3 |
| Johnsongrass | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Gulf cordgrass | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Tall dropseed | 18 | 17 | 5 | 2 | 2 | 2 | 4 | 4 | 3 | 2 | 8 |
| Smutgrass | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Texas wintergrass | 18 | 17 | 4 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 9 |
| Littletooth sedge | 9 | 9 | 6 | 5 | 5 | 5 | 9 | 9 | 4 | 4 | 35 |
| Flatsedge | 18 | 17 | 6 | 4 | 3 | 3 | 5 | 5 | 3 | 2 | 9 |
| Olney bulrush | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Cattail | 18 | 17 | 9 | 9 | 6 | 9 | 18 | 8 | 4 | 3 | 10 |
| Spiny aster | 0 | 0 | 0 | 5 | 4 | 0 | 7 | 6 | 0 | 0 | 0 |
| Ragweed | 18 | 17 | 11 | 9 | 9 | 9 | 16 | 16 | 5 | 3 | 8 |
| Wild indigo | 7 | 7 | 7 | 3 | 3 | 3 | 6 | 6 | 2 | 2 | 6 |
| Old-mans beard | 16 | 16 | 15 | 14 | 14 | 14 | 16 | 16 | 13 | 13 | 36 |
| Bundleflower | 18 | 17 | 4 | 3 | 3 | 3 | 5 | 5 | 2 | 1 | 8 |
| Mistflower | 18 | 17 | 9 | 9 | 7 | 7 | 17 | 8 | 4 | 3 | 7 |
| Camphorweed | 20 | 20 | 20 | 12 | 12 | 12 | 20 | 20 | 10 | 10 | 11 |
| Frogfruit | 14 | 14 | 12 | 11 | 11 | 11 | 13 | 13 | 10 | 10 | 35 |
| Snoutbean | 13 | 13 | 12 | 11 | 11 | 11 | 12 | 12 | 10 | 10 | 34 |
| Ruellia | 14 | 14 | 13 | 12 | 12 | 12 | 13 | 13 | 11 | 11 | 34 |
| Glasswort | 20 | 20 | 20 | 12 | 12 | 12 | 20 | 20 | 10 | 10 | 11 |
| Bush sunflower | 18 | 17 | 9 | 9 | 7 | 7 | 17 | 8 | 4 | 3 | 7 |
| Orange zexmenia | 18 | 17 | 5 | 3 | 3 | 3 | 4 | 4 | 2 | 1 | 7 |
| Giant ragweed | 30 | 30 | 29 | 27 | 25 | 25 | 33 | 32 | 24 | 24 | 35 |
| Partridge pea | 13 | 13 | 10 | 8 | 8 | 8 | 12 | 12 | 7 | 7 | 34 |
| Woolly doveweed | 31 | 31 | 32 | 31 | 26 | 26 | 31 | 30 | 25 | 25 | 34 |
| Broomweed | 31 | 31 | 31 | 30 | 28 | 27 | 32 | 31 | 27 | 27 | 36 |
| Sunflower | 18 | 17 | 9 | 9 | 6 | 5 | 19 | 9 | 4 | 3 | 6 |
| Sumpweed | 20 | 20 | 20 | 12 | 12 | 12 | 20 | 20 | 10 | 10 | 11 |

SDStems = standing dead stems; SDLeaves = standing dead leaves; SdlgRoot = seedling roots; SdlgShoot = seedling shoots

Appendix Table E.22 Cattle competition factors for plant parts, by species, in the Victoria County EDYS model. Values are relative rankings among competing herbivores for the respective plant material (1 = most competitive of the herbivores; 6 = least competitive).

| Common name | Croot | Froot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 6 | 6 | 6 |
| Pecan | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Hackberry | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Mesquite | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Post oak | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 6 | 6 | 6 |
| Live oak | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Blackbrush | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Baccharis | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Sea oxeye | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Granjeno | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| McCartney rose | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Rattlepod | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Greenbriar | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Mustang grape | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 |
| Prickly pear | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Big bluestem | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Bushy bluestem | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Purple threeawn | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Arrowfeather threeawn | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Silver bluestem | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Sideoats grama | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Buffalograss | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Sandbur | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Hooded windmillgrass | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Bermudagrass | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Saltgrass | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Virginia wildrye | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Pan-American balsamscale | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Plains lovegrass | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Switchgrass | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Longtom | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Brownseed paspalum | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Thin paspalum | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Common reed | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

Appendix Table E.22 (Cont.)

| Common name | Croot | Froot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Knotroot bristelgrass | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Plains bristlegrass | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Indiangrass | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Milo | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Johnsongrass | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Gulf cordgrass | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Tall dropseed | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Smutgrass | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Texas wintergrass | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Littletooth sedge | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Flatsedge | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Olney bulrush | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Cattail | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Spiny aster | 0 | 0 | 0 | 4 | 4 | 0 | 4 | 4 | 0 | 0 | 0 |
| Ragweed | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Wild indigo | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Old-mans beard | 6 | 6 | 6 | 6 | 5 | 5 | 6 | 5 | 6 | 6 | 6 |
| Bundleflower | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Mistflower | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Camphorweed | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Frogfruit | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Snoutbean | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Ruellia | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Glasswort | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Bush sunflower | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Orange zexmenia | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Giant ragweed | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Partridge pea | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Woolly doveweed | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Broomweed | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Sunflower | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Sumpweed | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

SDStems = standing dead stems; SDLeaves = standing dead leaves; SdlgRoot = seedling roots; SdlgShoot = seedling shoots

Appendix Table E.23 Accessibility of plant parts, by species, for consumption by cattle in the Victoria County EDYS model. Values are the percentage of standing crop biomass that could be accessed by cattle.

| Common name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Huisache | 0 | 0 | 1 | 10 | 10 | 5 | 10 | 10 | 10 | 40 | 20 |
| Pecan | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 80 | 5 |
| Hackberry | 0 | 0 | 1 | 2 | 2 | 1 | 2 | 2 | 0 | 25 | 0 |
| Mesquite | 0 | 0 | 1 | 10 | 10 | 10 | 10 | 10 | 0 | 40 | 2 |
| Post oak | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 10 | 70 | 50 |
| Live oak | 0 | 0 | 1 | 5 | 5 | 4 | 5 | 5 | 0 | 50 | 2 |
| Blackbrush | 1 | 1 | 90 | 95 | 90 | 90 | 95 | 80 | 10 | 50 | 10 |
| Baccharis | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Sea oxeye | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Granjeno | 0 | 0 | 90 | 95 | 80 | 10 | 90 | 50 | 5 | 40 | 0 |
| McCartney rose | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Rattlepod | 0 | 0 | 95 | 99 | 95 | 95 | 95 | 80 | 10 | 70 | 20 |
| Greenbriar | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Mustang grape | 0 | 0 | 5 | 5 | 5 | 4 | 5 | 5 | 0 | 5 | 0 |
| Prickly pear | 0 | 0 | 50 | 95 | 95 | 95 | 95 | 95 | 0 | 5 | 0 |
| Big bluestem | 1 | 1 | 40 | 90 | 90 | 95 | 90 | 90 | 10 | 50 | 0 |
| Bushy bluestem | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Purple threeawn | 0 | 0 | 5 | 95 | 95 | 90 | 95 | 95 | 0 | 5 | 0 |
| Arrowfeather threeawn | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Silver bluestem | 1 | 1 | 40 | 90 | 90 | 95 | 90 | 85 | 10 | 50 | 0 |
| Sideoats grama | 0 | 0 | 5 | 95 | 95 | 90 | 95 | 95 | 0 | 10 | 0 |
| Buffalograss | 1 | 1 | 20 | 80 | 75 | 40 | 80 | 70 | 5 | 20 | 0 |
| Sandbur | 10 | 0 | 40 | 70 | 80 | 95 | 70 | 80 | 40 | 50 | 0 |
| Hooded windmillgrass | 1 | 1 | 30 | 90 | 85 | 90 | 90 | 80 | 5 | 30 | 0 |
| Bermudagrass | 0 | 0 | 2 | 80 | 80 | 80 | 80 | 80 | 0 | 2 | 0 |
| Saltgrass | 10 | 0 | 40 | 70 | 80 | 95 | 70 | 80 | 40 | 50 | 0 |
| Virginia wildrye | 1 | 1 | 40 | 90 | 90 | 95 | 90 | 85 | 10 | 50 | 0 |
| Pan-American balsamscale | 1 | 0 | 99 | 99 | 80 | 90 | 99 | 50 | 20 | 80 | 0 |
| Plains lovegrass | 10 | 0 | 40 | 70 | 80 | 95 | 70 | 80 | 40 | 50 | 0 |
| Switchgrass | 0 | 0 | 5 | 95 | 95 | 95 | 95 | 95 | 0 | 10 | 0 |
| Longtom | 3 | 2 | 10 | 80 | 75 | 90 | 80 | 70 | 10 | 30 | 0 |
| Brownseed paspalum | 10 | 0 | 40 | 80 | 80 | 95 | 80 | 80 | 40 | 50 | 0 |
| Thin paspalum | 1 | 1 | 20 | 90 | 90 | 95 | 90 | 85 | 10 | 30 | 0 |
| Common reed | 10 | 0 | 40 | 80 | 80 | 95 | 80 | 80 | 40 | 50 | 0 |

Appendix Table E.23 (Cont.)

| Common name | CRoot | FRoot | Trunk | Stems | Leaves | Seeds | SDStems | SDLeaves | SdlgRoot | SdlgShoot | SeedBank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Little bluestem | 0 | 0 | 5 | 95 | 95 | 95 | 95 | 95 | 0 | 10 | 0 |
| Knotroot bristelgrass | 1 | 1 | 10 | 80 | 75 | 90 | 80 | 70 | 5 | 20 | 0 |
| Plains bristlegrass | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Indiangrass | 0 | 0 | 5 | 95 | 95 | 95 | 95 | 95 | 0 | 10 | 0 |
| Milo | 2 | 1 | 20 | 90 | 90 | 95 | 90 | 85 | 20 | 70 | 20 |
| Johnsongrass | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Gulf cordgrass | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Tall dropseed | 0 | 0 | 5 | 95 | 95 | 95 | 95 | 95 | 0 | 10 | 0 |
| Smutgrass | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Texas wintergrass | 0 | 0 | 5 | 90 | 90 | 90 | 90 | 90 | 0 | 5 | 0 |
| Littletooth sedge | 1 | 1 | 10 | 90 | 80 | 90 | 90 | 70 | 5 | 20 | 0 |
| Flatsedge | 0 | 0 | 5 | 90 | 85 | 90 | 90 | 85 | 0 | 5 | 0 |
| Olney bulrush | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Cattail | 5 | 5 | 50 | 90 | 90 | 80 | 90 | 90 | 0 | 10 | 0 |
| Spiny aster | 0 | 0 | 0 | 100 | 100 | 0 | 100 | 100 | 0 | 0 | 0 |
| Ragweed | 0 | 0 | 5 | 95 | 95 | 95 | 95 | 95 | 0 | 5 | 0 |
| Wild indigo | 5 | 0 | 50 | 80 | 80 | 95 | 80 | 80 | 50 | 50 | 0 |
| Old-mans beard | 1 | 1 | 10 | 70 | 80 | 80 | 70 | 70 | 5 | 20 | 0 |
| Bundleflower | 0 | 0 | 5 | 90 | 80 | 80 | 90 | 80 | 0 | 2 | 0 |
| Mistflower | 0 | 0 | 5 | 90 | 85 | 95 | 90 | 85 | 0 | 5 | 0 |
| Camphorweed | 5 | 0 | 50 | 80 | 80 | 80 | 80 | 70 | 10 | 40 | 0 |
| Frogfruit | 1 | 1 | 5 | 70 | 50 | 70 | 70 | 40 | 5 | 10 | 0 |
| Snoutbean | 1 | 1 | 10 | 75 | 60 | 80 | 75 | 50 | 5 | 10 | 1 |
| Ruellia | 1 | 1 | 1 | 60 | 40 | 60 | 60 | 30 | 1 | 5 | 0 |
| Glasswort | 5 | 0 | 50 | 80 | 80 | 80 | 80 | 70 | 10 | 40 | 0 |
| Bush sunflower | 0 | 0 | 5 | 90 | 85 | 95 | 90 | 85 | 0 | 5 | 0 |
| Orange zexmenia | 0 | 0 | 5 | 90 | 85 | 90 | 90 | 85 | 0 | 5 | 0 |
| Giant ragweed | 1 | 1 | 20 | 90 | 90 | 80 | 90 | 80 | 10 | 50 | 0 |
| Partridge pea | 1 | 1 | 5 | 80 | 70 | 70 | 80 | 60 | 10 | 30 | 1 |
| Woolly doveweed | 1 | 1 | 5 | 85 | 90 | 90 | 85 | 80 | 10 | 20 | 0 |
| Broomweed | 1 | 1 | 5 | 80 | 80 | 85 | 80 | 70 | 10 | 40 | 0 |
| Sunflower | 0 | 0 | 5 | 95 | 95 | 90 | 95 | 95 | 0 | 5 | 0 |
| Sumpweed | 5 | 0 | 50 | 80 | 80 | 80 | 80 | 70 | 10 | 40 | 0 |

SDStems = standing dead stems; SDLeaves = standing dead leaves; SdlgRoot = seedling roots; SdlgShoot = seedling shoots