THE INTERVENTION OF HUMAN MODIFICATIONS ON PLANT AND TREE SPECIES IN THE LANDSCAPE OF THE LBJ NATIONAL GRASSLANDS

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An analysis utilizing both ArcGIS and ethnographic interviews from private land owners and environmental professionals examined how man-made landscape changes affected plant and tree species in the LBJ National Grasslands in Wise County, Texas north of Decatur. From the late 1800s to the Dust Bowl Era the land was used for crop production and cattle grazing resulting in erosion and loss of soil nutrients. The research indicated by 2001 that cattle grazing and population increase resulted in land disturbance within the administrative boundary of the national grasslands. Participants expressed concern over the population increase and expansion of 5 to 10 acre ranchettes for cattle grazing common in modern times. Recommendations for the future included utilizing and expanding the resources already existing with environmental professionals to continue controlling erosion.

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Lastly I greatly appreciate my client, AJC Environmental LLC, for their support and patience. Jesse Todd, the principal investigator and co-owner, at AJC has been a co-worker and friend for a number of years. His excitement for the applied thesis idea and easily agreeing to be my client for this project was most beneficial. I was happy to provide the information he wanted and look forward to working with him in the future.

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CHAPTER I

PROJECT DESCRIPTION

Landscape modification occurs both naturally and through human interaction. The question examined with this applied thesis is how plant and tree species are affected by land altered for the supposed benefit of private land owners. The project looks at how plants and trees in the LBJ National Grasslands have been impacted by man-made changes to the region. The larger LBJ National Grasslands administrative boundary in north central Wise County includes approximately 20,000 acres of 78 federally owned grassland units surrounded by privately owned lands (United States Department of Agriculture 2011). The federal grasslands offer a better chance to observe what nature will do when human impact is minimal compared to some of the adjacent privately owned land.

The LBJ National Grasslands are located within the Western Cross Timbers ecoregion with the Grand Prairie ecoregion to the west and the Blackland Prairie ecoregion to the east (Griffith, et al. 2007:vi Figure 2). Prior to becoming the national grasslands the plots were originally bought by the government during the Dust Bowl Era in the 1930s (Hurt 1985:248). Currently, the few anthropogenic modifications largely consist of measures to control erosion (Personal communication with Austin Sewell). The soils vary from sandy loams in the Western Cross Timbers to clays in both the Grand and Blackland Prairies. The variation in soil types allows for different types of plant and tree species to flourish (Natural Resources Conservation Service N.D.). Some of the surrounding privately owned land, including farm and ranch land, can be compared with land modification through human intervention resulting in terracing, plowing and clearing of land for agriculture or grazing. The result of man-made landscape changes, such as

agricultural fields, can change which plants and tree species will develop (Dyksterhuis 1948:342 Table 3).

The research project is sponsored by AJC Environmental, LLC, a small Cultural Resource Management (CRM) firm based in Carrollton and a member of the Texas Women's Business Enterprise National Council (WBENC). Jesse Todd, the Principal Investigator, has 15 years of experience in the CRM field working primarily in North Central and Northeast Texas but also has experience in Louisiana and Oklahoma. AJC Environmental LLC's interests lie in the variety of soil types, sands, and clays used by the private land owners and on the federally protected lands within the 20,000 acre LBJ National Grasslands administrative boundary. The information gained from this project has the potential to assist AJC Environmental, LLC with future planning of archaeological investigations in the federally protected grasslands and Wise County.

Research questions:

1. How do private landowners and Forest Service employees in and around the LBJ National Grasslands classify the changes to the landscape in the past and present?
    A. What are their views on plant and tree species conservation?
2. How are environmental impacts different on public and privately owned lands?
    A. Do current land modification practices hinder the chance for successful biodiversity conservation on public and private lands?
3. How will land modification in the future affect the different types of soils, along with plants and trees in privately owned lands?
    A. Can conservation methods be introduced that will maximize flora biodiversity?
4. Using historical and modern data, can land modification in the future be anticipated and how will it affect the different types of soils, along with plants and trees in privately owned lands?

CHAPTER II

PROJECT DELIVERABLES

Two forms of written reports, one to AJC Environmental, LLC and the other to the applied thesis committee, will be distributed at the conclusion of the research project. The two written reports include a shorter form for the client composed of the description, context of work, project design, results, and references with additional information on the location of archaeological sites. A longer form for the applied thesis committee will have the addition of the discussion on the personal reflections gained from the research project. A PowerPoint presentation with the project design, methodology employed, and final results presented to the client and UNT Committee at the final defense of the applied thesis concludes the project.

CHAPTER III

CONTEXT OF WORK

The LBJ National Grasslands located in north central Wise County is surrounded by Montague and Cooke counties north, Denton County east, Tarrant and Parker counties south and Jack County to the west. Within the larger administrative boundary covering roughly 115 thousand acres are 78 federally owned lands encompassing approximately 20 thousand acres, or units, intended for wildlife or grazing surrounded by privately owned lands. Figure 1 shows the location of the grasslands and the adjacent counties.

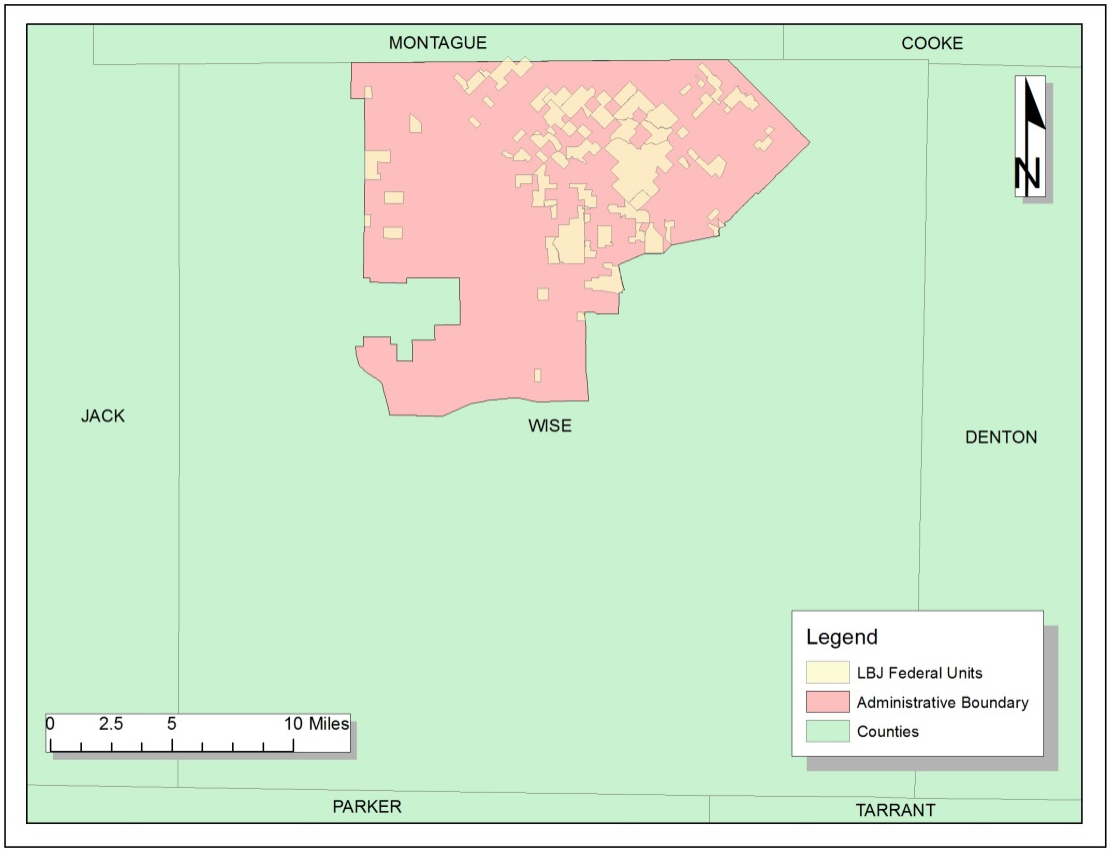

Figure 1. *LBJ National Grasslands in Wise County, Texas*

Land use and the corresponding modification, along with the effects on the plants and trees within the overall environment entails a number of important discussion points. First, the theoretical perspective of historical ecology frames the understanding of the overall research project. Second, the historical background comprises information on the national grasslands formation, use of fire and ethnographic accounts ranging from the 16th to the 20th Centuries. Third, the vegetation data for the Western Cross Timbers with two sources from the 1940s and 1950s, and three later sources from 1990 to 2007 deliberated. Lastly, plant and tree biodiversity research and study results from various locations in Minnesota, Texas and Kansas follow the plant and tree species information and listing.

Theoretical Perspective

The theoretical perspective of historical ecology set forth by Balée (1998, 2006) and Crumley (2007) attempts to bridge the gap between the life and social sciences by focusing on landscape. This perspective applies to the LBJ National Grasslands since both prehistoric and historic groups have altered its landscape in the past. The relationship between nature and culture is perceived as a historical dialogue with the intent of joining the two, thus preventing a dichotomy (Balée 1998:3,6). The application of historical ecology also assists to provide the conditions attempting to restore past landscapes using time depth and traditional knowledge (Balée 2006:75).

The historical ecology approach consists of four postulates placing importance on how human activities affect nearly all nonhuman landscapes. The first postulate, Homo devestans doctrine, implies that everywhere humans have occupied the biodiversity has lowered due to environmental mismanagement of animal and the spread of pollution. The second postulate

contradicts the first by stating that human activity does not always lower the biodiversity and can potentially increase the number of species over time. This postulate closely follows the Ecologically Noble Savage doctrine where the inhabitants do not lower the biodiversity of the environment they inhabit. The third postulate maintains that different political and economic systems within a regional context will result in different effects on the nonhuman landscape, and the historical account in the same regions. The final postulate implies that a total phenomenon will form with human community, culture, landscape and regions interacting over a period of time (Balée 1998:128-138).

Furthermore, historical ecology states that anthropogenic land modification is also influenced by policy enforcement. A hypothetical scenario described by Carole L. Crumley (2007) demonstrates how humans and nature are interrelated with the encouragement of sheep raising in upland locations through governmental policy. At first large areas of land are deforested, then overgrazing cause's erosion due to fewer grasses that help to hold moisture. Next grazing areas are reduced which in turn forces more uneroded areas to be overgrazed, leading to runoff of eroded soils into a valley. Because of the newly deposited soils in valleys land prices rise with more people moving to the area, and eventually adaptive strategies like counter plowing and reforestation take place (Crumley 2007:1-3). The scenario described by Crumley is comparable to what could have occurred in the LBJ National Grasslands area with the actions from European settlement leading up the Dust Bowl Era from intensive agriculture interweaved with a prolonged drought during the 1930s.

Historical Background

LBJ National Grasslands History

The historical background of the research project area cannot be explained without discussing the formation of the national grasslands themselves. The LBJ National Grasslands were 1 of 19 formed on June 20, 1960 from 22 former New Deal land utilization (L-U) projects in eleven western states. Land utilization projects were experiments run by the federal government employing land use reform to restore eroded grasslands and agriculture during the Dust Bowl Era. In 1942 the acres of crop land in the United States numbered 415 million, with 76 million not suitable based on safety and profitability (Hurt 1985:246, Lewis 1989:161, Unknown author 1942:576). The steps leading up the formation of the national grasslands involved a number of different policies and agencies. The initial policy, the 1929 Agricultural Marketing Act and the Federal Farm Board, decided which lands deemed submarginal based on erosion would be removed from cultivation. Next, the Land Use Planning Committee listed submarginal lands to purchase for L-U projects in 1932. A year later, the Federal Emergency Relief Administration (FERA) was established to buy submarginal lands, with dollars from the Public Works Administration.

L-U project areas continued to change hands until the current agency, the Forest Service took control. In 1935 the New Deal L-U projects were reassigned to the Resettlement Administration. Power then transferred to the newly formed Soil Conservation Service (SCS) under Title III of the Bankhead-Jones Farm Tenant Act of 1938. The SCS was responsible for erosional control methods with land use changes including listing, furrows, terracing, strip cropping, and artificial seeding. The SCS remained in control until November 2, 1953 when the

Forest Service, the current manager, took over the responsibilities of the L-U projects (Hurt 1985:248,249,258). The land, currently under the Forest Service management, set aside for L-U projects shrank from nearly ten million to four million acres with the selling of six million to various states and colleges in 1958. Finally two years later in 1960 the remaining four million acres became the national grasslands (West 1990:89).

The Dust Bowl Era and the environmental problems that ensued greatly influenced the formation of the National Grasslands within the United States. Agriculture spread rapidly by European settlement removing native prairie grasses and trees in North Texas covering the Fort Worth, Eastern and Western Cross Timbers, and Blackland Prairie ecoregions. The number of farms steadily increased in the United States from 1.5 million in 1900 to 6.25 million by 1930, along with the acreage cultivated corresponded accordingly with 177 million in 1880 to 413 million by 1931 (Brown 1936:338). The loss of native prairie grasslands to agriculture or animal grazing caused erosion due to the loss of top soil, with the Blackland Prairie experiencing the highest percentage. By 1915 it was estimated that the destruction of the original Blackland Prairie was nearly 100 percent due to agriculture plowing and the expansion of settlers in the 19th Century. The formation of the SCS under the direction of President Roosevelt's New Deal attempted to reduce the environmental impact of the Dust Bowl Era (Hurt 1985:248,249; Diggs Jr., et al. 1990:34,37).

The role of the Forest Service expanded over time since its conception early in the twentieth century. The National Forest Service (NFS) established in 1905 provided good quality water and timber intended for the Nation by Congress under the United States Department of Agriculture. The management powers of the Forest Service expanded within the national

grasslands, along with Congress authorizing further management of sustained yields of renewable sources such as water, wood, wildlife, and recreation. Other areas of management included wilderness, minerals, grazing, fish, and wildlife. In 2006 the Forest Service managed 155 forests, 20 grasslands, and 222 research or experimental forests covering 192 million acres of public land handled by roughly 30 thousand employees (National Forest Service 2006:36). Five important roles or activities are associated with the Forest Service: 1) protection and management of the natural resources on forest lands, 2) ensures research on all characteristics of forestry, rangelands, and resources within the public forests, 3) the government provides for the protection and management of non-federal forests in rural areas established with community assistance from local and state governments, forest industries, and private landowners, 4) the hiring of employees that reflect the broad diversity of the American people and 5) protect the world's forest resources through international and United States assistance in areas such as policy formation (National Forest Service 2006:36).

Land modification and the role of government policy intertwine with the timber industry managed by the Forest Service. However, the expanding role of the Forest Service over time and management of natural resources formed three myths. The myths include federal timber required to meet the increasing demand for wood fiber, timber sales profitable for the government, and federal timber aides other timber dependent neighbors. The first myth is false because 72 percent of the timbered lands are privately owned and the potential for better soil exists. With the second myth presently the federal government sells their timber at a fair market price compared to the private timber companies where a profit is not always achieved. Finally the third myth is debunked by federal policies stating that logging of certain areas is required by

policy, and not necessarily helping timber dependent neighbors (Knize 1991:99,100,103). Further examination would be necessary to determine the environmental impacts of the policy over the timber industry at the LBJ National Grasslands.

Fire Use

The use of fire assisted in shaping the history, landscape and vegetation within the Western Cross Timbers and LBJ National Grasslands region. Prior to the large settlement of farmers in the area ranchers did set fires on their rangelands. The recollection of the ranchers indicated that during drier seasons fires frequently burned off the tall grasses and the limbs off trees allowing a rider on horseback to move through the forest easily. European settlers attributed to vegetation change by overgrazing and utilizing "patch farming" practices. Patch farmers built structures and fences making fire dangerous for them, thus they suppressed fire (Dyksterhuis 1948:333). Fire suppression of Cross Timbers vegetation often established the quick return of understory vines and brush, post oaks and blackjack oaks including areas previously grasslands. The Fort Worth Nature Center tested the hypothesis by reduced burning and the post oaks and blackjack oaks did reappear rapidly. At a separate location within the nature center areas were burned with oaks disappearing and grasses reestablishing themselves (Francaviglia 2000:Kindle Edition). A picture of prairie grassland in Unit 49 of the within the LBJ National Grasslands is shown in Figure 2.

Fire study experiments examining plant and tree biodiversity provided additional data. Collins (2000) in his study examined whether plants, birds, grasshoppers, or small mammals exhibited directional change or stability with the introduction of experimental fire frequencies in relation to the watersheds. The pretext for the study came from past research at Konza Prairie

going back ten to fifteen years to determine whether spatial or temporal variability lead to community instability on the native prairie grasses. The prairie had been exposed to experimental fires every one, four, and twenty years after 1972, and before that the area was burned every two or three years with grazing as the primary land alteration (Collins 2000:311-312). The results demonstrated that plant communities under the annual burn plan showed the greatest alteration from those at the four or twenty year fire regimes, but the animal community showed no change. The plants were also undergoing a small degree of directional change on all the watersheds regardless of the frequency of fire was, and the animals demonstrated virtually none. At the four to seven year fire regime the vegetation underwent the most alteration in the plant community when compared with the twenty year fire regime. An example of the modification happens with big bluestem (*Andropogon gerardii*), a dominant species, decreasing by 50 percent since 1983, and little bluestem increasing by 25 percent on annually burned areas (2000:311-312).

In addition to plant composition changes the species richness and spatial heterogeneity decreased at the annual burn regime. The more frequent the fire intervals allowed for grass biomass to increase and often coincided with a decrease in forbs and shrubs in tallgrass prairies. Fire intervals every twenty years changed the landscape again with reduced tallgrass prairie species and increased woody species invasion, and net nitrogen transforming the area into shrublands or woodlands. Collin concluded that higher rates of fire have not stabilized the tallgrass prairies and that a patchwork of different vegetation regions often occurs instead at the Konza Prairie (Collins 2000:317-319,322).

The Crosstimbers Trail at the Nature Center contains a post oak and blackjack oak forest as it might have appeared in the 1800s with old growth forests. Francaviglia visited the center in

1997 when all the leaves were on the trees describing a wooded area thick with vegetation only allowing visibility a few yards (Francavigila 2000:Kindle Edition). Visiting the nature center in 2015 during the winter the trees were still close together forming a canopy-like cover over the trail with 30 feet tall, or taller, post oaks scattered throughout the region. Figure 3 shows the Crosstimbers Trail in the Fort Worth Nature Center taken in January of 2015.

Figure 2. *Grassland Area in Unit 49 of the LBJ National Grasslands*.

Figure 3. *Crosstimbers Trail in the Fort Worth Nature Center*.

Ethnographic Accounts

The third component of the historical background, ethnographic accounts, discusses the inhabitants of the LBJ National Grasslands region, and Wise County, largely from the European settler's point of view. Accounts of the early indigenous Native American groups from the 16th and 17th Centuries in North Texas offer the least reliable ethnographic accounts. According to Dr. Bascope with the Botanical Research Institute of Texas the original inhabitants, the time frame not specified, were probably nomadic gatherers/hunters based on sparse archaeological data, but very little evidence has been found to properly describe how they lived or used the land. The most commonly associated North Texas tribes including the Caddo, Wichita, Apache,

and Comanche arrived later most likely as seasonal hunters (Personal communication with Dr. Bascope 4-15-13).

A myth that Native Americans were stewards of the land and lived in a pristine environment exists. Denevan states that evidence from vague ethno-historical accounts, field surveys and archaeology that in 1492 the landscape modified by Native Americans included the expansion of forests, grasslands, and building of mounds widespread before large European settlement. The modifications impacted the soil, microclimate, wildlife and hydrology. The way the land appeared in 1750 was more pristine, or less humanized, when compared to 1492 due to the population decrease of the Native Americans (1992:370).

Beginning in the 18th century information about Native Americans became more reliable and accurate. The primary source for the time period around the American Revolution came from Juan Agustín de Morfi, a Franciscan monk, famous orator, and theology professor. The work of Morfi has endured due to the 1932 translation by Carlos Eduardo Castañeda where large numbers of passages describe the daily lives of Texas Indians. The account includes passages detailing how the indigenous groups managed or modified the land (Maury Skeels 1972:24,25). One such account talks about the Wichita, labeled as the Quitzels Nation, Indians territory in North Texas:

> Eighteen leagues north of the abandoned Bucareli was situated a pueblo of the Quitzels Nation, their numbers being 20 armed at the most. They possess a very beautiful valley where they cultivate the land, and maintain their horse herds. Nearby are many salt beds, where they can freely supply their wants. The main body of this nation united with the Cadognoches. (Maury Skeels 1972:32)

Another example from the 1932 translation further demonstrates how the Tuacana Nation, or Wichitas:

> …occupied two pueblos on the banks of the Brazos. The first [Tuacana village] called Quiscat was situated on the western bank, at a distance of 31 leagues from Bucareli, in a fertile plain, and defended from the floods by a high hill, which protects it on the river side. From the side of the hill springs an abundant stream of good water; which is used by the inhabitants…for irrigating their fields, but they are not aware of this advantage, and depend on rainfall for their crops. About 150 warriors live in this place. (Maury Skeels 1972:32)

Later in the 19th century historical accounts portrayed a more accurate relationship between people and their interaction with the environment. Changes in the ethnographic accounts occurred during this time period with both Native American and European land uses described. In present day Tarrant County an account from De Shields about Birds Fort in 1841 tells how the settlers did not bring a large enough supply of provisions based on the environment when they discovered that the Indians burned much of the ground surface. According to the account because of the burning no wild game could be located, resulting in a wagon sent back to restock the settlers (Baker and Cage 1962:10). Another account from John Peter Smith details that in 1853 "there were indians of the Caddo, Waco, and Ionian tribes scattered throughout this section. Their camp fires could be seen dotting the prairies at night in every direction around Fort Worth" (Baker and Cage 1962:14).

Vegetation Sources

Sources for vegetation in the past and relative present examined the plant and tree species within the LBJ National Grasslands and the surrounding ecoregions. Problems occur when attempting to determine which species are native and those introduced into the grasslands and forested regions. It is important to note that the Soil Conservation Service (SCS) after 1937 experimented with different grasses for the reseeding of the highly eroded areas. It was determined that in harder soils blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua*

curtipendula) and buffalograss (*Buchloe dactyloides*) were best suited for harder soils. In sandier soils blue grama, sand lovegrass (*Eragrostis trichodes*), sideoats grama, little bluestem (*Schizachyrium scoparium*) and sand bluestem (*Andropogon hallii*) demonstrated better characteristics for prairie restoration (Hurt 1985:254).

Dyksterhuis in 1948 described the vegetation in the Western Cross Timbers using four coverage categories in which includes the location of the LBJ National Grasslands: Quercus-Smilax, Quercus-Prosopis, Prosopis, and Old-field (Dyksterhuis:342). The Quercus-Smilax coverage found on gentle to rolling terrain contained large numbers of post oak (*Quercus stellate*), blackjack oak (*Quercus marilandica*) at 25.8 percent of the total. saw greenbrier (Smilax bona-nox) made up the second largest percentage at 10.4 percent, followed with sideoats grama, texas winter grass (*Stipa leucotricha*) at 3.7 and 3.6 percent, hairy grama (*Bouteloua hirsuta*) at 2.7 percent, coralberry (*Symphoricorpos orbiculatus*) at 0.2 percent. Undescribed forbs represented 19.5 percent of the total for the coverage area. Quercus-Prosopis found in areas of the roughest terrain with reddish prairie soils were the next coverage. Present again was post oak and Blackjack oak, at 11.7 percent, along with buffalograss at 12 percent. Threeawns (*Arista* spp.) runs in at 6.6 percent, hairy grama at 2.8 percent, texas grama (*Bouteloua rigidiseta*) at 0.5 percent, blue grama at 0.3 percent, western wheatgrass (*Agropyon smithii*) at 0.2 percent, buckley (*Triodia pilosa*) at 0.3 percent. The unidentified forbs were at a higher percentage again of the overall total at 19.8 percent (Dyksterhuis 1948:342).

The other two coverage types set forth by Dyksterhuis, Prosopis and Old-field, differed from Quercus-Smilax and Quercus-Prosopis. The chief difference being that post and blackjack oak were marginally represented. The Prosopis coverage type was located in areas of flat to

gentle terrain with buffalograss having been the most abundant at 20.1 percent and little barley (Horeum pusillum) next at 14.1 percent. Other vegetation included texas wintergrass present again representing 8.3 percent, hairy grama at 3.8 percent, texas grama and blue grama again at 0.8 and 0.4 percent, along with buckley at 0.3 percent. The non-described forbs are rated large in percentage at 12 percent, but unidentified again. The last coverage, Old-field, is associated with cultivated, cleared, or abandoned lands noted by the near absence of post and blackjack oaks. The highest plant percentage assigned went to western or cuman ragweed (*Ambrosia psilostachya*) at 6.8 percent, followed by walter (*Festuca octoflora*) at 5.8 percent, and threeawns at 3.7 percent (Dyksterhuis 1948:342). A complete list of all the vegetation types can be found in Appendix A.

In 1950 Frank Blair observed and recorded the biotic provinces of Texas describing the various plants, trees and animals for each. A total of six biotic provinces were described: Chihuahuan, Kansan, Balconian, Tamaulipan, Texan, and Austroriparian (Blair Figure 1:98). In the LBJ National Grasslands, the two provinces represented in the research area and surrounding region are the Texan and Kansan extending from Oklahoma into Texas. Plant species documented by Blair in the Kansan Province were threeawns, sideoats grama, and blue grama. The Texan province contained western wheatgrass, buckley and texas wintergrass, along with post oak, blackjack oak, and hickory (*Caya buckleyi*). The Kansan biotic province consisted of broomweed (*Gaillardia texana*), gaillardia (*Gaillardia puchella*), hairy grama, sideoats grama, blue grama, along with the absence of hickory (*carya* spp.),post oak and blackjack oak (1950:100-102). Dyksterhuis and Blair described the same plant and tree species for the Western Cross Timbers.

A complete list of all the plants and trees in the Texan and Kansan provinces by Blair is in Appendix B.

A later source of vegetation types came from Steve L. Orzell who inventoried the National Forests and Grasslands in Texas for his Master's thesis in 1990. The LBJ National Grasslands were one of the areas inventoried and comparable with the earlier sources from Dyksterhuis and Blair. Three tasks assigned by Orzell were to: 1) compile a list of sensitive plants, 2) identify plant communities and classification and 3) make land management recommendations (Orzell 1990:1,2). A large quantity of plant species are part of earlier lists by Dyksterhuis and Blair including threeawns, hairy grama, sideoats grama, texas grama, saw greenbriar, silver bluestem (*Bothriochloa saccharioides*), western ragweed, coralberry, post oak, blackjack oak and cedar elm (*Ulmus crassifolia*). Species listed only by Ortiz are shumard red oak (*Quercus shumardii*), texas live oak (*Quercus fusiformis*), eastern red cedar (*Juniperus virginiana*), and sugarberry (*Celtis laevigata*).

One significant difference between Orzell, Dyksterhuis and Blair is a better description of forbs by Orzell including broomweed (*Gutierrezia dracuncuioides*), fragrant sumac (*Rhus aromatica*), mountain pink (*Centarium beyrichii*), compact prairie clover (*Dalea compact var. pubescens*), prairie clover (*Dalea tenius*), longleaf buckwheat (*Eriogonum longfolium*), bluedaze (*Evolvulvus pilosus*), gumweed (*Grindelia squarrosa*), texas yellowstar (*Lindheimera texana*), lemon beebalm (*Monarda citriodora*), smartweed leaf-flower (*Phyllanthus polygonoides*), pitcher sage (*Saliva azurea*), compass plant (*Silphium laciniatum*) and purple prairie verbana (*Verbana bipinnatifida*) observed. The possibility exists that these and other forb types could have been

present in the earlier Dyksterhuis and Blair accounts but just not described or detected. A complete list of all the plants and trees from Orzell is found in Appendix C.

A second later source of plant and tree identifications comes from Diggs, et al in 1999 covering North Central Texas incorporating an area of approximately 40,000 square miles and fifty counties. The vegetation areas described are the Blackland prairie, Eastern Cross timbers, Western Cross timbers, Fort Worth prairie, Lampasas Cut plain and Red River areas (Diggs Jr., et al. 1999:3). The vegetation zone applicable to the current research is the Western Cross timbers zone. The grasses recorded by all three previous sources and Diggs, et al included hairy grama and sideoats grama, and those by only Dyksterhuis are tall dropseed (*Sporobolus asper*), switch grass (*Panicum virgatum*), and canada wildrye (*Elymus canadensis*). Texas wintergrass is recorded in the early sources from Dyksterhuis and Blair, but not Ortiz. Post oak and blackjack oak trees are represented in all three previous sources, along with hackberry (*Celtis spp*) and cedar elm recorded in both early and later sources. Trees new to the overall 1990 inventory included honey mesquite (*Prosopis glandulosa*), pecan (*Carya illinoinensis*) and juniper (*Juniperus* spp.). Appendix D lists all the plant and tree types listed by Diggs et al.

A third modern source comes from a 2007 report presented to the Texas Commission on Environmental Quality (TCEQ) that determined the vegetation, geology and topography in Texas. In the Westerns Cross Timbers ecosystem, a section of the larger Grand Prairie, the plants and trees in the Upland forest included post oak, blackjack oak, cedar elm, black hickory (*Carya texana*), live oak, eastern red cedar and sumac (*Rhus* spp.). The riparian forest adjacent to waterways in the east contained pecan, Black willow (*Salix nigra*), eastern cottonwood (*Populus deltoides*), sycamore (*Platanus* spp.) and boxelder (*Acer negundo*) vegetation. The western

riparian forest had honey mesquite, hackberry and little walnut (*Juglans microcarpa*). The relatively undisturbed areas were composed of big bluestem (Andropogon gerardii), little bluestem, yellow indiangrass (*Sorghastrum nutans*), switchgrass and sideoats grama. The understory is listed as buffalograss, purple threeawn (*Aristida purpurea*), curlymesquite (*Hilaria belangeri*), honey mesquite and lotebush (*Ziziphus obtusifolia*). The grazed sections populated with understory shrubs and vines included persimmon (*Diospyrus* spp.), sassafras (*Sassafras* spp.), greenbriar (*Smilax spp*) and virginia creeper (*Parthenocissus quinquefolia*) (Griffith, et al. 2007:40).

Biodiversity

Biodiversity studies vary from one region to another based on factors such as lands use, ecosystem function, scale, soil types and seed types (LaCroix and Abbadie 1998, Huston 2005, Tillman and Downing 1994, Polley, et al, 2005, Freeman and Hulbert 1985). Studies in the LBJ National Grasslands related to biodiversity included inventories of the vegetation (Orzell 1990) and witness tree data from GLO records (Jurney, et al. 1989). Links between biodiversity and ecosystems usually focus on the nutritional impact in relation to energy flows, species richness impacts, and sustainability (LaCroix and Abbadie 1998). Patch to patch biodiversity and disturbance regimes including land use changes of land abandonment, along with habitat fragmentation with clear cutting and urbanization as examples offer improved analysis attributes. Another common problem is properly assigning the correct scale that best represents the link between the biodiversity and ecosystem, and a variety of temporal spatial and times scales. Historical disturbances, manmade and natural, must also be considered since they affect current biodiversity; ignoring this factor can lead to misunderstandings of the environmental

conditions. Finally the environmental factors influencing the overall processes of ecology have to be examined, and not just the nutritional or reproductive scopes (LaCroix and Abbadie 1998:189-191).

Another way to examine how land use change and the urban/rural population will affect biodiversity places emphasis on environmental properties and primary productivity instead of traditional economic factors. Three phases described by Huston affecting overall biodiversity are agricultural, industrial, and informational or communication. The agricultural phase has little impact on areas of low productivity, while high productivity lands, like intensive croplands, often reduced biodiversity. Submarginal lands, like those that formed on sections of the national grasslands, are an example of reduced biodiversity. The industrial phase uses more lands that were once not originally cultivated during the agricultural phase, and population density can be reduced in rural areas with more people moving to cities. In the informational or communication phase the human population again returns to the rural properties, and low productivity lands once not used during the agricultural phase are cultivated. A consequence of the various land uses in relation to the productivity by the three stages is that impacts on the biodiversity are less towards smaller plants and animals. However, large vertebrate animals will be negatively impacted by the land use changes since they have the greatest competition for the same land (Huston 2005:1864,1875).

Outside of the LBJ National Grasslands area studies in other grasslands include experimentation and plant and tree species observations. A study in Minnesota conducted an eleven year examination of ecosystem stability and the corresponding biodiversity (Tillman and Downing 1994). A total of 207 control and experimental plots placed in four grassland fields

examined where the plant species richness were altered by using seven varying rates of nitrogen addition beginning in 1982. Drought conditions experienced in 2 of the 11 years and the corresponding results demonstrated that some species survived in harsh environmental conditions. Overall biodiversity promoted resistance to disturbances (Tillman and Downing 1994:363-365). Although not the same environmental setting as the LBJ National Grasslands similar, or dissimilar, results could occur in North Texas since drought conditions are a common problem and agricultural and animal grazing are practiced.

A Texas study conducted in the Blackland Prairie ecosystem east of the LBJ National Grasslands examined biodiversity (Polley et al. 2005). Observations at three locations compared remnant plots with replanted restoration grasses to observe the rate of biodiversity that occurred in each at different spatial scales. Restored tallgrass prairies were implemented by placing seed hay from remnant fields into previously cultivated fields. The results demonstrated that in all the different time scales the remnant grasslands had the highest biodiversity, species composition, and richness. Resource partitioning improvements in the remnant grasslands also contained more functional groups with fewer species per group than compared to the restored prairie grasslands. The overall results were consistent with previous studies that local processes such as seed dispersal and resource partitioning help to improve the overall biodiversity (Polley, et al. 2005:480-481,485-486). The difference between the LBJ National Grasslands and this study is primarily the soil types. Despite the soil difference, the information gained along with the biodiversity results could be similar, since both areas could experience similar drought conditions. One problem lies in that the LBJ grasslands have already been reseeded during L-U

projects in the 1930's and 1940's, so determining native versus exotic, remnant or not, provides a greater challenge.

The Konza Prairie in northern Kansas contains similar characteristics with the LBJ National Grasslands through similar terrain and soil types located in the Flint Hills region. The land was acquired in 1977 by the Nature Conservancy in order to study the preservation of a diverse prairie region in a natural setting. Kansas State University conducts ecological research using the Konza Prairie, one of eleven Long-Term Ecological Research (LTER) sites in the United States (Freeman and Hulbert 1985:84-85). The soils within the LBJ National Grasslands and the Konza Prairie are similar with both areas containing loamy clays and silty or sandy loams. The primary difference is that the Konza Prairie has more loamy clays and less silty or sandy loams compared to the LBJ Grasslands where the opposite is true (Natural Resources Conservation Service, N.D.) Taxonomic studies of native and exotic plant species occur in both areas, and in the Konza Prairie 468 plant species from 107 different families based on observations from 1972 to 1983 have been demonstrated. A similarity with the LBJ National Grasslands lies with the oak family (*Quercus spp*), but they are bur oak (*Quercus macrocarpa*) and chinquapin oak (*Quercus muehlenbergii*), instead of the post oak and blackjack oaks at the LBJ National Grasslands (Freeman and Hulbert 1985:81-83).

CHAPTER IV

RESEARCH DESIGN

Recruitment Techniques

The LBJ National Grasslands encompasses a large area of land. Interviews from private land owners and environmental professionals and an ArcGIS analysis of various landscape data were used to gain a better understanding of the research questions. Two different methods were used to recruit participants, a search of land owners employing public access computers at the Wise County Appraisal District Office and a visit to a local feed store in Bridgeport. The public computer access search looked for land owners with 100 acres or more, calling the number given on the records and attempting to arrange an interview. Recommendations for other people from participants who agreed to be interviewed further assisted with valuable information. A visit to a local feed store where local land owners patronize with owner permission constituted the second method with willing participants completing a one page questionnaire after agreeing and signing the consent form. The interview questions are in Appendix E and local feed store questionnaire in Appendix F.

Data Collection

A collection of both quantitative and qualitative information comprised the data for the research project. Quantitative data sources used in conjunction with the Geographic Information System (GIS) analysis using the ArcGIS software program 10.1 with environmental information gathered from public websites (www.tnris.org, www.water.usgs.gov), Bruce Hunter with the Center for Spatial Analysis and Mapping, and the Associate Director of the Institute of Applied Sciences at the University of North Texas in Denton. Archaeological sites within the study area

were provided by the Texas Historical Commission at www.atlas.thc.state.tx.us/texsite/texsite-main.asp. Examples of GIS data included soils, ecoregions, topography, geology, land cover patterns, historical maps, and aerial photographs. In order to expand the understanding of the local private land owners and professionals working within the LBJ National Grasslands interviews were conducted with them. Questions asked of the willing participants interviews included what plants and trees they considered native, non-native, how the landscape looked in the past, how they envision the landscape in the future, and how long they have lived on the land, and potential threats to the environment.

Data Analysis

As with the data collection different methods of analysis for the collected data were required of the quantitative GIS shapefiles and qualitative interviews from local participants. The analysis of GIS data using ArcGIS first required determining the environmental factors for examination and locating the shapefiles. ArcGIS allowed for the layering of multiple components forming an analysis, along with the ease of removing or adding elements. Within the shapefiles extraction of selected data and placement into maps pertaining to specific groups, such as soils and land cover data, composed the next step. After grouping came the analysis section by investigating layers of the specific groups looking for patterns within the environmental setting in the LBJ National Grasslands. Additionally, a predictive model using ArcGIS's "fuzzy logic" based on specific criteria examines how the grassland/herbaceous gridcode coverage could look like in the future.

The qualitative part of the research relied on interviews from private landowners and environmental professionals working for governmental agencies within the larger administrative

boundary and the 78 federally owned grassland units. The participants were each assigned a letter designation to provide anonymity. Information obtained from the interviews was then transcribed using Microsoft Word 2010 allowing for manual coding based on the research questions for the project. Manual coding of the smaller number of interviews was more effective compared to using software such as atlas ti. Additionally a demographic questionnaire filled out by ten of the eleven interviewees provided general information for the overall analysis. As with the ArcGIS analysis, once all the ethnographic data was coded the search for patterns of agreement or disagreement among the participants formulated the final results.

CHAPTER V

RESEARCH RESULTS

Demographics

Ten participants answered demographic questionnaires out of the eleven total participants interviewed. The information gained in the form of multiple choice answers determined factors such as age, gender, ethnicity and marital status. The largest age group (Figure 4) were those 55 to 64 totaling four, or 40 percent, followed with three at 65 or older at 30 percent, two at 45 to 54 with 20 percent, and lastly one 35 to 44 at ten percent. The male gender made up entirely 100 percent of the participants and was the only unanimous demographic value. Those within the white ethnicity category comprised the greatest percentage at 90 percent totaling nine individuals followed with one African American at ten percent. The marital status of the participants primarily were married totaling seven at 70 percent, trailed by two single individuals at 20 percent and one divorced at ten percent.

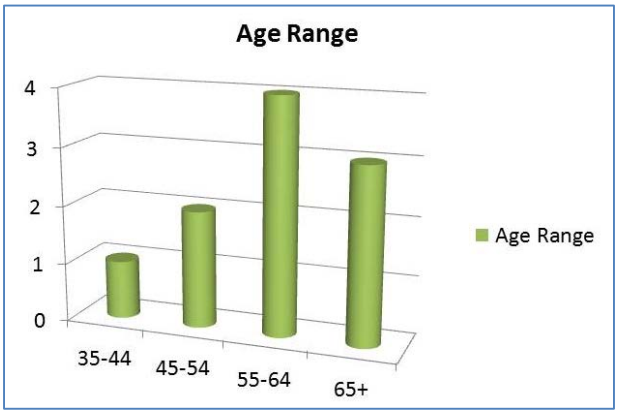

Figure 4. *Age Range of the Research Participants*

The demographic results continued with education level, annual income, religion importance and political leaning. The level of education varied slightly with four having some

college and four a bachelor's degree equaling 80 percent of the total. The remaining two categories of associate degree and high school graduates each comprised one participant for 20 percent. Annual income ranges (Figure 5) varied the most with those earning 25 thousand to 149,999 dollars, four different categories, each having two qualifying participants for 80 percent overall. The remaining two participants earned 150 thousand dollars or more for 20 percent. Religious importance (Figure 6) was nearly unanimous with six agreeing, 60 percent, and four strongly agreeing for 40 percent. Lastly the political leaning of the individuals interviewed varied with republican having the largest slot with five individuals encompassing 50 percent. The other 50 percent is composed of two independents, 20 percent, one democrat at ten percent and the remaining two covering the last 20 percent.

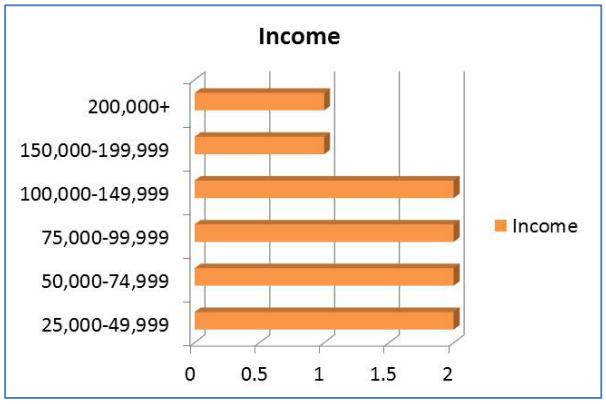

Figure 5. *Income Ranges of the Research Participants*

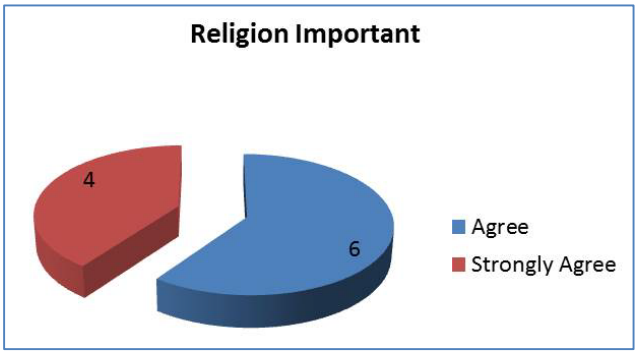

Figure 6. *Religion Importance of the Research Participants*

GIS Data

Soils and Geology

A number of soil types exist within the administrative boundary of the LBJ National Grasslands. The soil types, Figure 7, were classified into groups based on the description from the Soil Survey of Wise County, Texas (Ressel 1989:iv). The groups were loams, gullied soils, stony loams, eroded loams, flooded loams, stony clays, clays, flooded clays and quarry soils. The top three groupings were loams comprised of 25 soils, eroded loams with five soils, and flooded loams with four different soil types. Some of the soils include Arents loamy (Ar), Keeter very fine sandy loam with 1-6 percent slopes (KtC), Truce fine sandy loam with 2-5 percent slopes (TuC3) and frequently flooded Pulexas (Pu). Table 1 shows the acreage and percentage for each soil groupings and Appendix E lists all the soil types associated within each grouping.

In many cases certain soil groupings are associated with specific topographic terrains and settings. The loams and stony clays are commonly located on upland ridges, hilltops, terraces and some slopes. The flooded loams and flooded clays groupings are observed along the creeks and drainages with two main creeks traversing the national grasslands from north to south, the Big Sandy Creek to the west and Denton Creek to the east. Tributaries associated with the flooded loams and clays for Big Sandy Creek are Watson Branch, Walker Branch, Twin Pond Creek, Sandy Creek, Pringle Creek, Mudhole Branch, Grapevine Creek, Dry Hollow, Chicken Creek, Brushy Creek and Briar Branch. Denton Creek to the east has Rush Creek, Panther Creek and Cottonwood Creek.

Table 1. *Soil Groupings Reclassified within the LBJ National Grasslands*

Soil Groups	**Acreage**	**Percentage**
Loams	62768.36	55.89
Eroded Loams	20871.08	18.59
Flooded Loams	16312.33	14.53
Stony Loams	5448.42	4.85
Gullied Soils	4418.29	3.93
Clays	1526.3	1.36
Flooded Clays	659.65	0.59
Stony Clays	190.05	0.17
Quarry Soils	104.91	0.09
Total	**112299.39**	**100%**

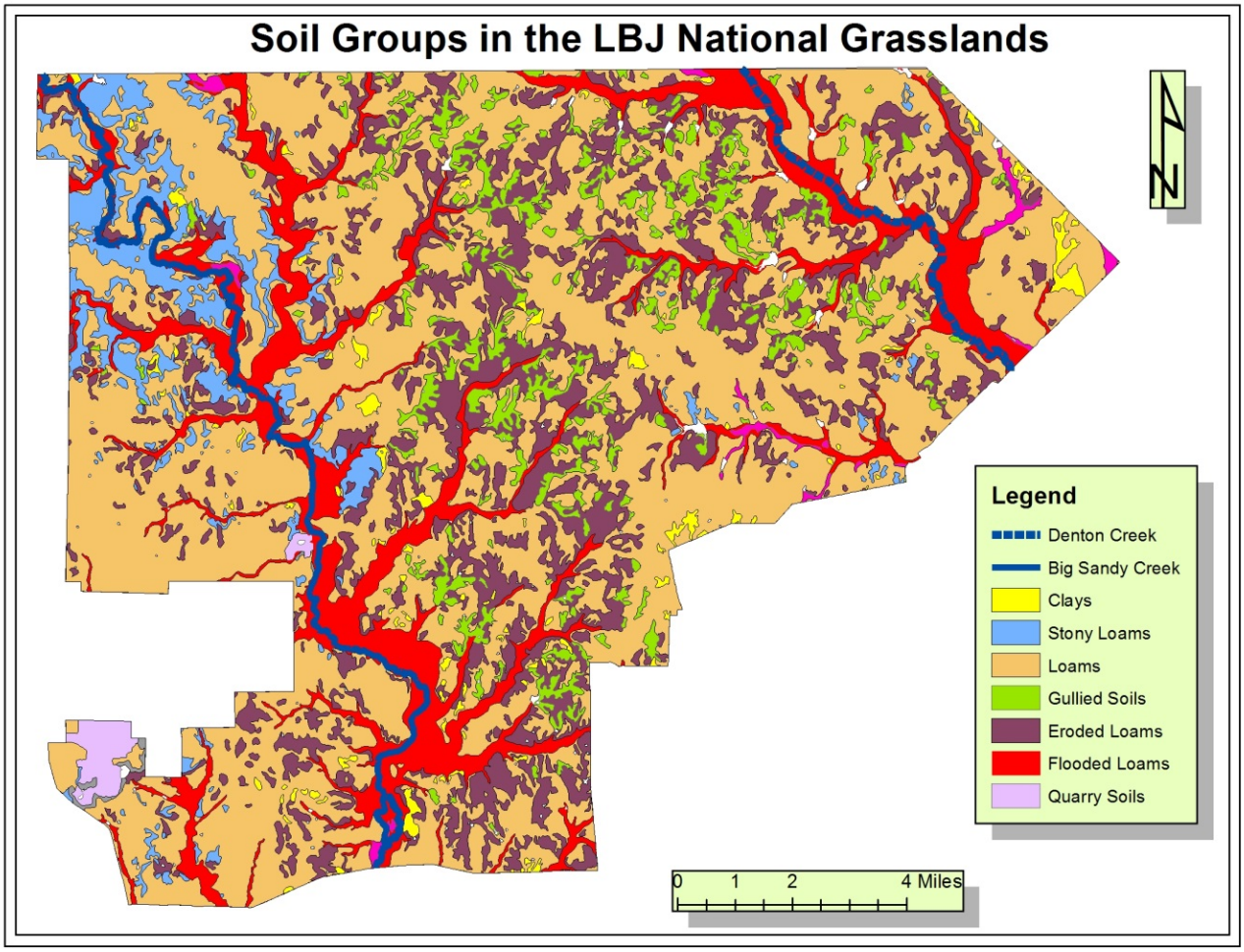

Figure 7. *Soil Groups in the LBJ National Grasslands*

Geology of the research area consists of ten underlying rock types with one type the most prominent. Antler sand (Ka) from the early Cretaceous period comprises the largest area covering 88.5 percent of the LBJ grasslands administrative boundary with Alluvium (Qal) from the Holocene period, the second largest, at 5.42 percent. The eight remaining rock types, all under three percent of the total, include Pennsylvanian fine grained clastic Jasper Creek Shale at 2.21 percent, along with early Cretaceous Goodland limestone and Walnut clay undivided at 1.75 percent. A complete list of all the geology types is shown in Table 2. Antler sand is the principal

geology type for the research area with no real comparison for changes in plant and tree species over time available based solely on geology.

Table 2. *Geology Types within the LBJ National Grasslands*

Unit	Designation	Rock Type	Acres	Percent
Ka	Antler Sand	Sand	102149	88.56
Qal	Alluvium	Sand	6252	5.42
IPjc	Jasper Creek Shale	Fine grained clastic	2550	2.21
Kgw	Goodland Limestone and Walnut Clay Undivided	Limestone	2023	1.75
PiPma	Sandstone	Sandstone	1149	1.0
Qt	Quaternary Terrace Deposits	Terrace	680	0.59
IPcr	Chico Ridge Limestone	Limestone	374	0.32
Kpa	Paluxy Sand	Sand	137	0.12
Kgr	Glen Rose Limestone	Limestone	26	0.02
Ktm	Twin Mountains Formation	Sandstone	11	0.01
Total			**115351**	**100**

Land Cover

National Land Cover Databases (NLCD) provided information on how land use changed throughout time to determine areas affected by human landscape modification. The data collected labeled as gridcodes fell under multiple categories ranging from open waters to high intensity development. The national grasslands contain 22 gridcodes with open waters, high intensity developed, deciduous forest, and pasture/hay as examples of the types of land use

categories. A complete list of all gridcodes can be found in Appendix F. Originally the NLCD files came in jpeg format which was converted to shapefiles using ArcGIS allowing for quantitative data analysis. Three different NLCD data sets were downloaded corresponding to the years of 1992, 2001 and 2006. Not all of the gridcodes require an explanation of change from 1992 to 2006 due to the values not changing overtime. Additionally some of the gridcodes lacked data until the 2001 NLCD download, thus the acreage numbers show little or no difference from 2001 to 2006. Predominately the greatest change in the landscape occurred between the years 1992 and 2001.

Several of the gridcodes have noticeably changed just since 1992 including open waters, low intensity developed and high intensity developed landscapes. Open waters, gridcode 11, any open area with less than 25 percent cover, soil or vegetation, decreased with a loss of 642 acres or 45 percent. Low intensity development, gridcode 22, increased dramatically from 1992 to 2001 with only slight upward change in 2006 with a 74 percent increase encompassing a gain of 1196 acres. Low intensity development includes a combination of constructed materials, such as single-family housing, and vegetation with 20 to 49 percent surface cover. A majority of the development occurred along US Highways 81/287 and 380, county roads, farm to market roads and private roads. High intensity development, grid code 24, rose from 4 to 29 acres from 1992 to 2001 and maintained the same acreage in 2006 with an 87 percent gain. The city of Alvord had the greatest percentage of high intensity development, along with scattered sections adjacent to low intensity developed land. Figures 8 and 9 show the illustrated gridcodes and how they have changed over time.

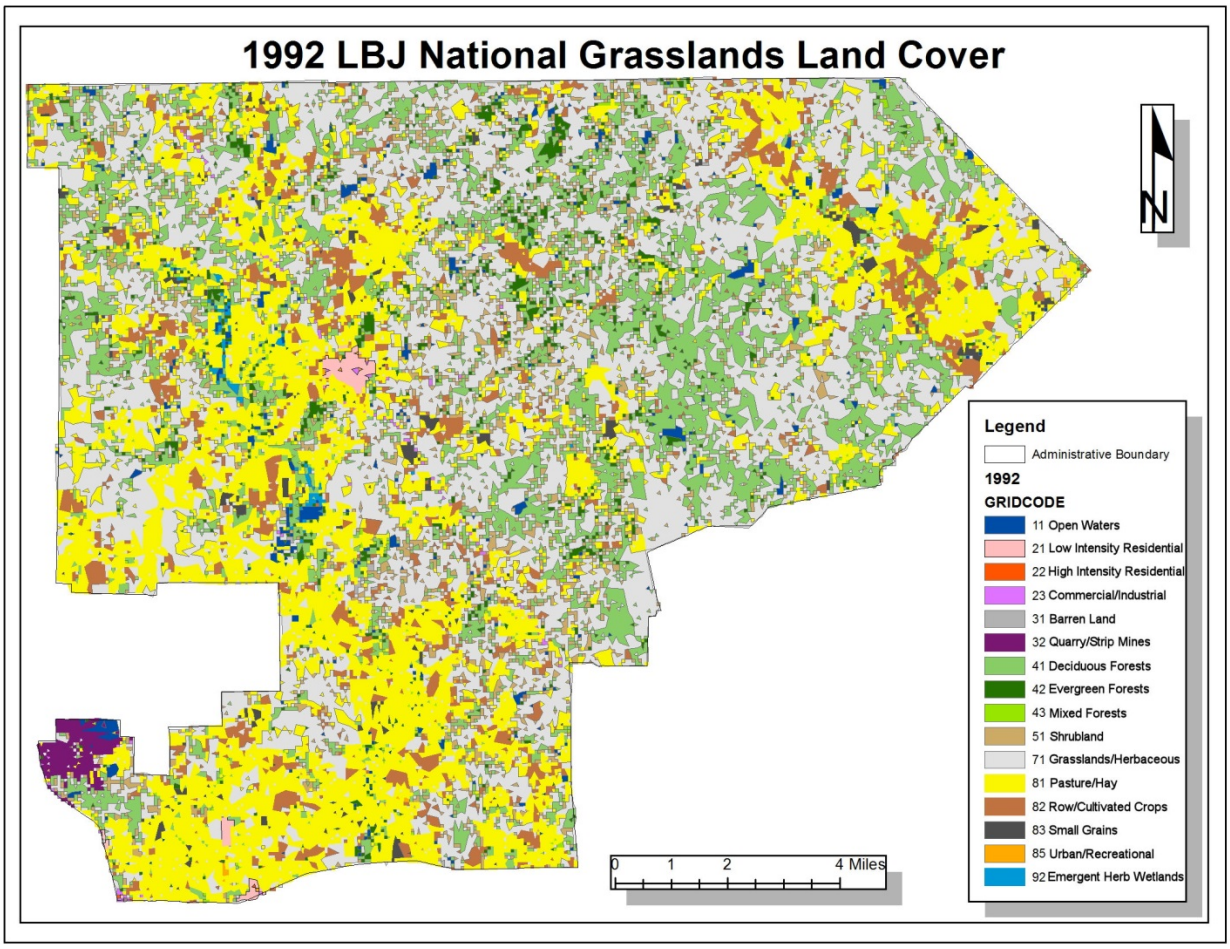

Figure 8. *1992 LBJ National Grasslands Land Cover Gridcodes*

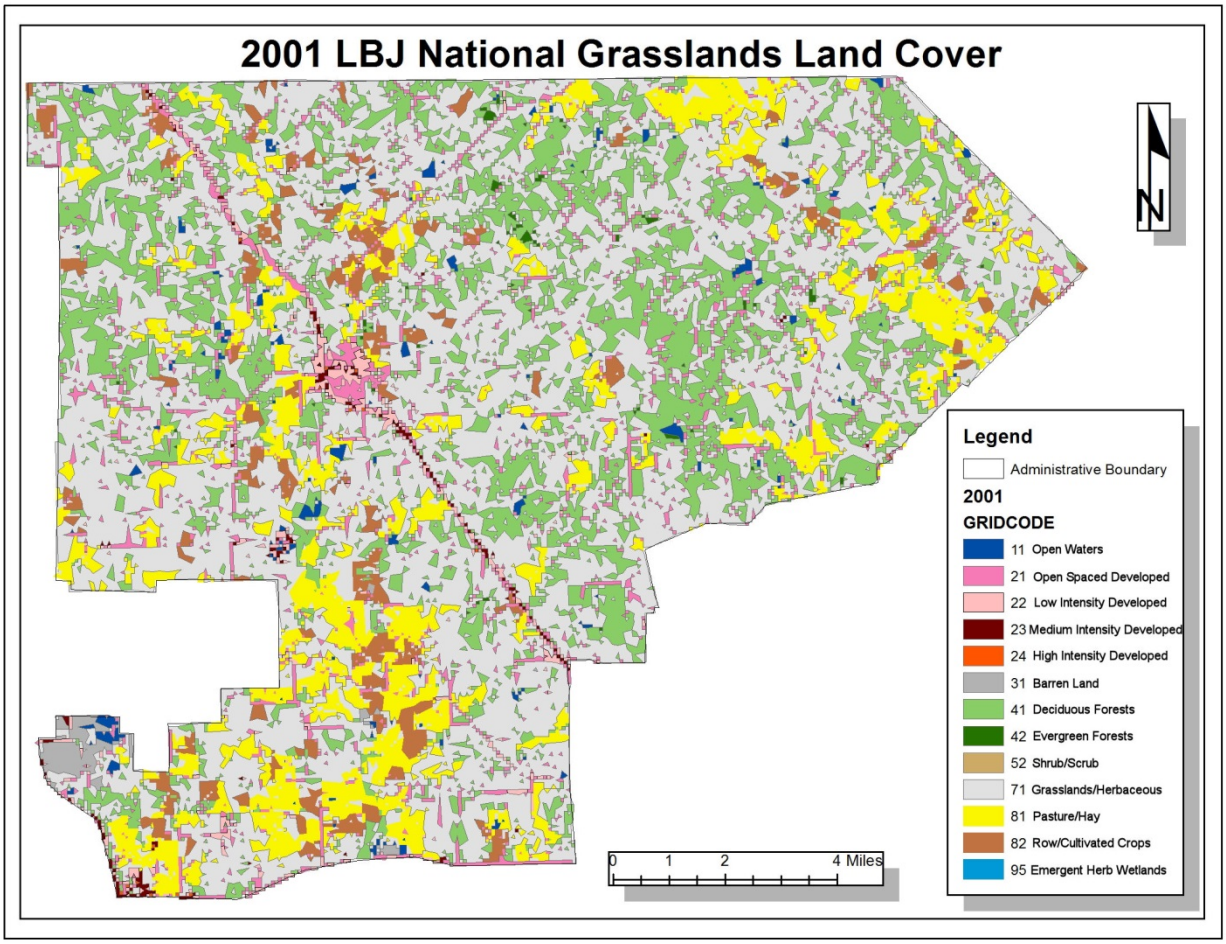

Figure 9. *2001 LBJ National Grasslands Land Cover Gridcodes*

GIS data showed barren land, deciduous forest and evergreen forest were areas of significant change. Barren land, gridcode 31, rose 89 percent from 88 acres in 1992 to 684 in 2001 and finally 768 by 2006. Areas with bedrock, sand dunes, strip mines, gravel pits and other earthen material where vegetation is less than 15 percent constitutes barren land. The size of the plotted changes range from 1.4 to 476.1 acres and are scattered throughout the national grasslands administrative boundary. Deciduous forests, gridcode 41, are defined as areas dominated with trees larger than five meters tall, greater than 20 percent vegetation cover and where the leaves drop in the fall on 75 percent of the trees. Deciduous forests increased from

19,608 acres in 1992 to the highest in 2001 with 24,640 acres in 2001 before dropping off slightly to 24,429 by 2006 with an overall average of 20 percent increase. At the same time evergreen forests, gridcode 42, decreased from 2580 to 205 acres from 1992 to 2006, with the greatest loss by 2001 with 97 percent average over time. The difference between deciduous and evergreen forests lies in that evergreens maintain at least 75 percent of leaves year round.

Additional gridcodes representing significant land use changes include grasslands/herbaceous and pasture/hay. Grasslands/herbaceous, gridcode 71, are areas with 80 percent or greater grass and herbaceous vegetation used for grazing but not intensely managed. Grasslands/herbaceous increased to 61,755 acres in 2001 from the previous number of 43,904 acres gaining incrementally to 61,946 by 2006 by 29 percent. Locations where grasses and grass-legume combinations are greater than 20 percent of total vegetation and utilized for either livestock grazing or hay crops comprise gridcode 81 pasture/hay. The 1992 database listed 30,466 acres of pasture/hay; however by 2001 the total lowered to 14,062 acres and 14,035 by 2006 for a loss of 54 percent overall.

Another loss of acreage comes from row/cultivation crops covering greater than 20 percent of the ground including all lands actively tilled and used for the production of annual crops such as corn, vegetables, cotton and soybeans. In addition perennial woody crops like orchards and vineyards fall under the same definition. Row/cultivated crops in 1992 covered 7707 acres and reduced to 4587 acres by 2001 and then slightly rose back up to 4626 acres five years later. It is possible that the reduction in acreage for both the pasture/hay and row/cultivation crop grid codes could account for the increase in the acreage of the grasslands/herbaceous areas. The 2001 NLCD data also shows that open space development,

along with low intensity and medium intensity development adjacent to county and farm to market roads contributed to the expanded grasslands/herbaceous vegetation.

Vegetation

Compared to soils, geology and land cover information sources on vegetation proved more challenging. Additionally observing an overall change based on GIS data was difficult since the data collection time period is similar to land cover gridcodes in which the results do not show much variation. Firsthand GIS data, scattered, was available for vegetation from Dr. Hunter with the UNT Geography Department with invasive weed and early seral plant source shapefiles. Changes in vegetation were also similar to certain gridcodes within the land cover gridcodes of deciduous forests (41), evergreens (42), grasslands (71) and pasture (82) providing a broader scale of environmental change with vegetation.

The seral status of vegetation defined as secondary, or intermediate, plant and tree development with four stages towards a stable climax phase helps explain some of the changes that cannot be determined with GIS data obtained for the current research. Potential Natural Community (PNC) is the first stage comprising the original vegetation dominant with seral species rare. The second stage is Late seral with PNC species still dominant, but more seral types present. Mid seral designation shows the seral plants and trees increasing in numbers coming close to equal percentages with PNC types. Lastly early seral vegetation describes when seral species become foremost with PNC classes very low in numbers or completely absent (Hall, et al. 1995:3). Early seral vegetation changes could help explain how the biggest change to the environment occurred overtime with Western Cross Timber forests of post and blackjack oaks replaced with cleared fields or pastures in areas.

Archaeology Sites

Multiple historic, prehistoric and multi component archaeological sites are recorded throughout the LBJ National Grasslands. Multi component sites contain both prehistoric and historic artifacts in a single site. A total of 60 sites are located within the boundaries of the LBJ National Grasslands according to the Texas Archaeological Site Atlas (TASA). The sites are comprised primarily of prehistoric lithic scatters and buried settings, along with historical farmsteads and a lime kiln (TASA N.D., Accessed 12-16-14). The prehistoric time frame includes the period before European settlement during the 1840's. TASA records designate the Middle Archaic period as the earliest time frame for the research area based on one Carrollton point found at site 41WS108. The Late Archaic, Late Prehistoric I and II, Historic Native American and Historic Anglo-American time periods (Table 3) cover the remaining sites because of no diagnostic materials recovered (Prikryl 1990:49).

Table 3. *North Central Texas Archaeology Chronology*

Historic European/American	110 B.P. to Present	A.D. 1840 to Present
Historic Native American	250 to 110 B.P.	A.D. 1700 to 1850
Late Prehistoric II	750 to 250 B.P.	A.D. 1200 to 1700
Late Prehistoric I	1250 to 750 B.P.	A.D. 700 to 1200
Late Archaic	3500 to 1250 B.P.	1550 B.C. to A.D. 700
Middle Archaic	6000 to 3500 B.P.	4050 to 1550 B.C.
Early Archaic	8500 to 6000 B.P.	6550 to 4050 B.C.
Paleoindian	Pre 8500 B.P.	Pre 6550 B.C.

A correlation exists between the soil types and archaeological site locations. All of the site locations are observed on loamy soil settings specifically loams, eroded loams, flooded loams, gullied soils and stony loams. Loams have the most even distribution with 15 prehistoric, 15 historic and four multi-component sites, but this is not surprising since loams cover the greatest acreage within the national grasslands. Eroded loams are the least distributive with historical sites predominant at 15 total along with two multi-component and one prehistoric location. Gullied soils are also represented in all three site types with much smaller numbers though, two for prehistoric, one for historic and one for multi-component. Two prehistoric and one unidentified site type are located in flooded loams, and lastly stony loams only have two prehistoric sites recorded.

The time period with the greatest number of sites lies within the Historic Anglo-American timeframe. According to the TASA website 34 out of the 60 sites are historic with all but one a homestead or farmstead. The farmsteads range in condition from nothing left but artifact scatters on the surface to buildings left standing such as houses and out buildings. In other cases just a foundation is left to determine the location of a historic site. The remaining historical archaeological site was a lime kiln built into the already eroded side of a gully (TASA N.D., Accessed 12-16-14). Historic sites are often located on ridges and hilltops in uplands where the soils consisted of loams, eroded loams, flooded loams, gullied soils and stony loams.

Prehistoric sites make up the second largest number for the LBJ National Grasslands administrative boundary. Prehistoric sites, 19 in number, describe lithic scatters or quarries with unknown time frames due to lithic chert, not diagnostic points, found on surfaces or in shovel tests. There is one exception where one site, 41WS108, does have a diagnostic chert point

allowing for a specific time frame to be assigned, which is the Archaic period. The single chert point designates the earliest time frame based on the artifacts recovered from all of the sites in the research area (TASA N.D., Accessed 12-16-14). The soil groups associated with prehistoric sites are loams, eroded loams, flooded loams, gullied soils and stony loams at various elevations just like the historic sites. Figure 10 shows the number of sites, however due to proprietary reasons the locations cannot be shown in order to prevent looting.

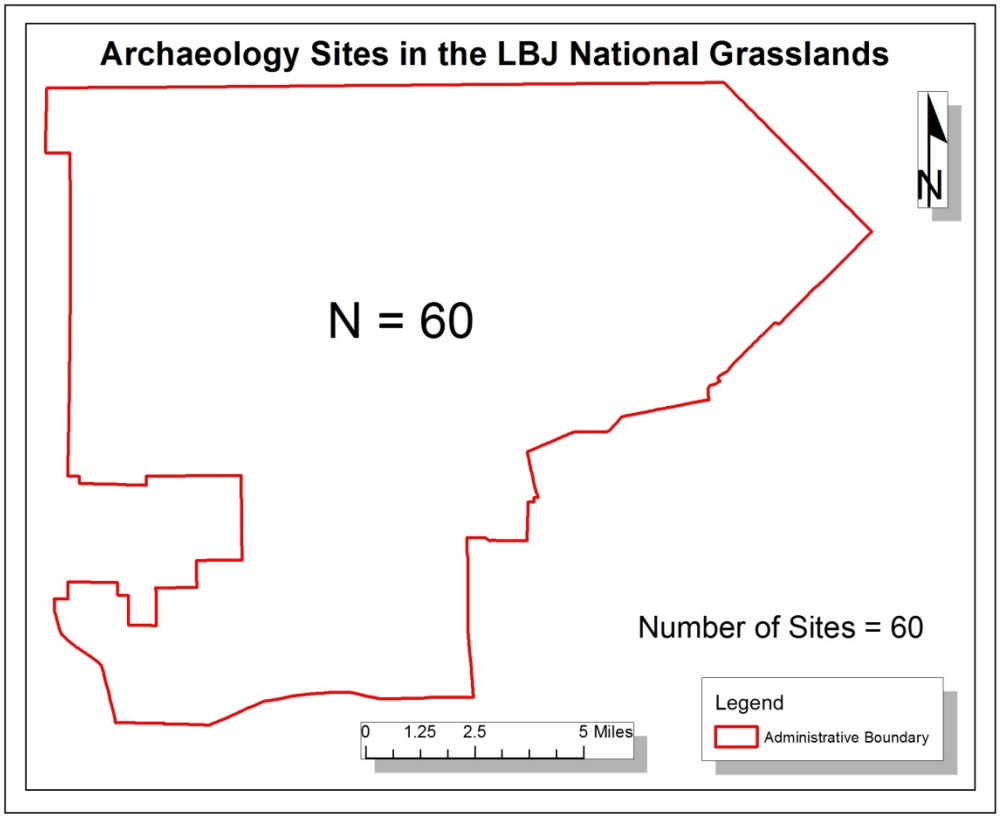

Figure 10. *Archaeology Sites in the LBJ National Grasslands*

The multi-component sites having both prehistoric and historic elements in one location comprise the third largest grouping of sites. Seven sites were recorded from the 1980s to the present with lithic scatters and farmsteads the most common site types. As with the previous historic and prehistoric sites not enough information was available to determine a specific time

frame for either both components. The artifacts recovered were from the surface and subsurface, with the historical often on the surface only (TASA N.D., Accessed 12-16-14). Soil associations for multi component sites are limited to loams, eroded loams and gullied soils often near creeks on uplands or slight slopes.

The degree of modification on the landscape varies according to the site type described in TASA. Prehistoric sites often display the least environmental disturbance due to the perceived short duration the locations were occupied in the past. Most of the prehistoric sites were surface sites not requiring much alteration of the land. An example is a quarry where people of the past gathered lithic material on the surface or just below the surface for tools used in conjunction with hunting or cooking. Other prehistoric sites are buried, as those located on the banks of waterways where sediment builds up as time passes due to periodic flooding.

Historic sites associated with agriculture and ranching are thought to be more destructive towards the natural environment, because farming and ranching typically involve much larger scale land clearing. Landscape change included cutting down forested areas of post oaks and blackjack oaks in order to have more acreage for cultivation fields. Lime kilns required large amounts of wood to turn limestone into lime, sometimes as much as one cord per furnace load. In historic times lime was invaluable for the production of concrete, mortar, plaster and stone construction materials. Additional sources for lime included softening water, reducing butter acids, making tortillas, tanning leather, killing termites and weevils and whitewashing (Smith 2010, Accessed 1-27-15). The Penobscot Marine Museum in Maine studied line kilns and determined that a typical kiln required 1000 cords of wood per year if ran continuously (N.D., Accessed 1-1-15). The measurement for a cord of wood is four feet tall by four feet wide by eight

feet deep, or 128 cubic feet total. The clearing of the forested areas within the LBJ National Grasslands in the late 1800's could include the operation of lime kilns. According to Marshall Patmos an estimate of 50 trees five foot in diameter would be required to produce one cord of wood (2005:1). The diameter of post oak and blackjack oak tends to be half that size or smaller requiring even more deforestation to operate a typical lime kiln.

An Archaeological example of environmental land use mismanagement comes from the largest pre-European settlement in North America mound building complex, Cahokia, in present day western Illinois. The complex flourished from the 10th century and continued for approximately 350 years adjacent to the Illinois, Missouri and Mississippi Rivers. Environmental degradation over time from deforestation for agricultural fields to feed an expanded population eventually caused erosion, runoff and downstream flooding during the important growing seasons. A series of wooden palisade walls constructed provided protection around the central part of the city; however this action required deforestation on a large scale. Archaeological evidence shows that the palisade wall was rebuilt three times during the habitation of Cahokia. In the end social and economic culture clashed resulting in declining crop production for the local farmers was believed to lead to the abandonment of Cahokia (Wood 2003:255,259).

Ethnographic Data

Semi-structured interviews from private landowners and environmental professionals within and around the LBJ National Grasslands provided information on how plant and tree species potentially changed over time due to human intervention. A total of 11 interviewees agreed to participate in the research project with eight private landowners and three environmental professionals working within and around the project area. The resulting data

delivered land use patterns past and present, perceived native vegetation, perceived introduced vegetation, fire use and environmental factors.

Land Use Past and Present

Private land owners often provided information on land use past and present because of first hand or family knowledge of the area. Five of the eight land owners have lived, or their families have, within the LBJ National Grasslands from 42 to 70 years with the remaining three land owners unknown or less than a year. Sometimes the data was non-determinant with Participant D listing how long they lived in the area as “all my life”, which could mean 42 plus years or less than one. The three environmental professionals also supplied information on land use with knowledge of the past and present, but how long they have lived in the research area was not obtained.

Cattle grazing and hay production represent the main economic activities in the LBJ National Grasslands. Presently, cattle grazing dominates the landscape among the private land owners, but this is only determined by the small number of those interviewed. Two of the participants, A and B, own ranches with 600 and 676 acres respectively used for cattle grazing with limited hay production for cattle. The number of acres owned decreased for the remaining participants with 163, 160, 80, 57, 15 and 6. Cattle grazing is the most common land use with the exception of Participant F who grows hay for cattle. Participant C’s family originally farmed the land over a century ago, however switched to mostly cattle grazing with limited farming. In addition a section of the land was a portion of the original Homestead Act land grant. The switch from agriculture to grazing was due to the erosion of the topsoil from poor farming methods earlier in time.

Participants described land use changes in both the past and present. Participant B provided strong background information for the research area with firsthand accounts and recollections of conversations with his father. Farming was the common land use earlier in twentieth century with cotton, corn, and wheat often planted, and according to his father "if it's not in timbers it was farmed". Of the acreage currently owned by him and his wife 240 out of 600 previously belonged to his father and mother, and before that eight families had been raised on the same property. Many of the eight families raised on the 240 acres lived in barrack like structures, most likely as tenant farmers. The continuous farming of the land caused the topsoil to erode, and in conjunction with a long drought in the 1930s, especially 1934, assisted in the formation of the Dust Bowl Era.

Information about the cotton industry comes from Roger L. Dixon who planted and sold cotton for 60 years starting around 1910. The cotton industry lasted for 80 years beginning during the reconstruction period after the Civil War and extended to 10 years after World War II. In 1912 cotton was king in Bowie, north of the LBJ National Grasslands, due to the sandy soil and then recently plowed up top soils. A low point in production occurred in 1929 when the stock market crashed and an extended drought in West Texas and Oklahoma caused the cotton crops to completely fail two years in a row (2009:i,14,37).

Other land modifications in the past included terracing, land clearing, construction of stock tanks and dairies. Terracing became common after the Dust Bowl Era in order to control erosion of the topsoil in planted fields and mentioned by four of the participants directly. Participant D specified that terracing was used for the watermelon and peanut crops, along with some cattle grazing. The other three participants just mentioned that terracing was used to

reduce erosion after the Dust Bowl Era. Land clearing identified by four of the participants fell under clearing of invasive brush and trees, for hay fields, mesquites for pastures, and timber removal along waterways. Lastly two participants talked about stock tanks and a dairy farm constructed in an earlier unknown time period.

Environmental professionals, Participants I, J and K, provided information on the background of the LBJ National Grasslands and land use. Deep gullies formed from planting crops such as wheat, corn and cotton starting with European settlement in the late 1800s. Some gullies were deep enough in the 1930s and 1940s that they resembled "baby grand canyons". After purchasing the land the newly formed Soil Conservation Service (SCS) in the late 1930s began planting seeds to try to return dirt back to grasslands and repairing gullies with gully plugs to stop further erosion. The Civilian Conservation Corp (CCC) in the 1940s also constructed gully plugs and other erosional control structures using small masonry bricks.

Research participant responses stated that modern land modifications still largely consist of environmental improvements. The biggest difference appears to be that private land owners and environmental professionals work together in a common interest to conserve the landscape. Improvements such as flood control dams help with water control and supply water for cattle, along with improved grasses for grazing on private lands. Environmental professionals work with private land owners to solve problems entailing grade stabilization structures, diversion terraces, grass planting and native grass restoration. In the end though environmental professionals only consult land owners on the best methods for land improvements. Overall, how much the land owner wants to spend on land improvements determines the level of landscape change. In the federally owned lands horse trails, camping locations and other recreational areas have been

built. Improvements include erosional control structures, reseeding of native seeds in old fields to stabilize the soil and limited cattle grazing.

Native and Introduced Vegetation

Private land owners and environmental professionals described both native and introduced plants and trees in the LBJ National Grasslands. The major difference between the two groups of participants primarily resides in the level of expertise in identifying plant and tree species. Environmental professionals identified more species of vegetation, especially grasses, compared to private land owners. Similarly, what is considered native or introduced can differ slightly between the two participant groups based on the data collected during interviews and questionnaire answers. Overall more research participants identified more native species compared to those introduced.

Native plants and trees described by participants outnumber the perceived introduced vegetation. The most straight forward response came from Participant I stating that anything before white settlement is native. White settlement did not begin in Wise County and the research area as a whole until the mid-nineteenth century with the first official survey not until 1852 (Jurney, et al 1989:90 Table 8). Participants frequently identified creeks as location for native trees. Native trees identified by participants were post oak, blackjack oak, live oak, burr oak, red oak, pecan, cedar elm, water elm, redbud, texas ash, hawthorne, eastern red cedar, cottonwood, mesquite, mexican plum, mulberry, bois d' arc, and hardwoods. In smaller numbers grasses comprised lovegrass, bluestem, little bluestem, indian grass, switch grass, sideoats grama and native grasses, along with blazing star flower and sunflower and the viney greenbriar. One land owner added that more brush, mesquite and cedars are present now than in the past.

Historical sources help verify that some of the trees and plants identified by the participants are indeed native based on pre-white settlement in the county. Before the forests in the Western Cross Timbers were cleared after European settlement specific trees were used as witness trees for the Wise County surveys under the General Land Office (GLO) starting in 1852. The witness trees that correlate with the participants' native trees were cottonwood, mesquite, blackjack oak, burr oak, pin oak, post oak and elm (Jurney, et al. 1989:86 Table 6). On Cactus Hill in 1855 Mrs. D.J. Galbraith described Col W.H. Hunt's home on a hilltop where Lake Bridgeport is currently located with live oak trees and cactus of all varieties (Cates 1907:41). In 1907 a woodland belt covered two-thirds of the Western Cross Timbers, or the Upper Cross Timbers, in Wise County. Trees that are in common with the participants' choices as native included post oak, pin oak, burr oak, water oak, red oak. Black walnut, pecan, cottonwood and elm were recorded along streams, while post oak and blackjack oak located on uplands (Cates 1907:355).

Additional historical sources from the nineteenth century help to verify the participants' choices as native vegetation. Richard V. Francaviglia discussed the North American Cross Timbers providing information on nineteenth century vegetation. The publication Texas in 1840, or *The* Emigrant's Guide to the New Republic described the Western Cross Timbers as diverse with blackjack oak, post oak, live oak, mixed in with elm and cedar. William Kennedy was an Irish diplomat and writer who in the 1830s traveled around the United States and the Texas Republic. In 1844 Kennedy wrote *Texas: Its Geography, Natural History, and Topography* and included blackjack oak, white oak, post oak, holly, hickory and elm as common trees for what is now called the Western Cross Timbers (Francaviglia 2000:Kindle Edition).

Research participants more readily identified native plants and trees compared to introduced species. By far the most common grass chosen by private land owners and environmental professionals was coastal Bermuda. Continuing with grasses old world bluestem, KR bluestem, plains bluestem, bromes, thistles and seresia were mentioned more by the environmental professional participants. The number of trees described as introduced was greatly reduced compared to native types with memosa spreading in the grasslands, honey locust, black locust, and generic pine. Cedars were considered introduced by some of the participants and a bradford pear planted in one of the participant's front yard. Mesquite and honey mesquite trees were also recognized as introduced and native.

Planted cash crops not surprisingly were considered introduced by private land owners with cultivation requiring clearing of forested areas or plowing up of grassland prairies. Most of the time, the native vegetation is removed to allow for the introduced species. Crops described by the research participants included cotton, corn and wheat, along with peanuts and watermelon in the past. Both peanuts and watermelon are no longer widely grown in Wise County, because soil nutrient loss made the crops not economically viable. Early in the 20th Century Cates described the Wise County area upland sandy soils highly productive for a wide variety of crops including cotton, wheat, oats, rye, barley, sorghum, kaflie, milo maize, melons, fruits and vegetable (1907:355-357).

Environmental Factors

Land use and vegetation only account for part of the LBJ National Grasslands change, other environmental factors command attention. The first factor, control burns are examined to see how management differs from private and federally owned units within the administrative

boundary of the LBJ grasslands. Second, the use of chemicals or organic methods by research participants to maintain crop and grazing lands. Third, potential damages facing the natural environment, such as prolonged drought and tree diseases. Finally how will the oil and natural gas industry effect the environment and land use in the future.

Control burns used within the LBJ National Grasslands happen only on a limited basis. Interviews concluded that private land owners concurred unanimously that control burns are rare on their properties. Participant A expanded saying that a fear of damaging their land and house often prevented them from burning, even though control fires occurred on the federally owned units immediately adjacent to their property. Environmental professionals work with private land owners recommending modifications to improve the landscape from erosion and other problems. As the population increases in Wise County the environmental professionals seldom recommend control burns.

The situation is different on the 78 federally owned units within the administrative boundary where control burns have been performed on a yearly basis since the late 1990s. Participant I expressed two different ideas relating to the annual burning schedule. The first idea considers the vegetation for wildlife, livestock and agriculture in the federal units of the national grasslands. Originally the need for fire control was based on simple factors of what units were ready at the time, safe to burn and the resources available. Now landscape scales look at the importance of specific environmental settings, such as vegetation supporting quail, to decide which units are annually burned. All 78 units within the LBJ National Grasslands are assigned to one of three categories based on their environmental setting importance. The first rate category entails the most important units requiring burning first because of identified environmental

issues. Second rate units are not as important and will be burned if resources allow, and third rate units are not nearly as important and often are not burned. The second idea considers public safety by setting control burns to potentially lower the risk of wildfires in the future. The Forest Service manages the control burns for wildfire prevention since it is primarily a firefighting organization.

While the environmental professionals recommended organic methods, private land owners primarily relied on chemical fertilizer. All but one of the private land owners use or used chemical means to fertilize bermuda grass, improving hay production, removing brush and killing weeds. The fertilizer Triple 15 was designated for use on coastal bermuda to keep the grass growing and improve seed. A single land owner gave the opinion of "have not" on the questionnaire, which could apply towards organic or chemical methods. Most participants agreed that cattle prefer coastal bermuda grass over native species requiring the use of chemical fertilizers. Any lapse in the use of chemicals on coastal bermuda often allows the more resilient native grasses to return in their place.

Environmental professionals share a different view on the use of chemicals to control plants and trees. Inside the grasslands federally owned units, professionals seldom used chemicals except to eradicate invasive aquatic plants, water mussel and hydrilla, largely leaving the other vegetation natural. The environmental professionals working with land owners recommend more organic methods over chemical use. Cover crops and plant combinations with mixtures of grasses to build up the soil to improve organic and biological properties of soil are pitched to land owners as a viable option.

Potential damage towards the environment as quantified by the research participants varied from unknown to drought. The potential damage with the greatest frequency was drought and the effects on the land, cattle and vegetation. The environmental professionals agreed that native species would survive better in drought conditions because they have been through previous droughts in the past. Participant A commented on previous drought conditions in 1956, believed to be the hottest, and again in 1980 when the temperature reached 113 degrees causing newborn calves to die in the fields if they could not reach shade. A study looking at records of drought were traced from 1698 to 1980 based on climatic post oak tree ring data using the June Palmer Drought Severity Index (PDSI). Data from the years of 1951 to 1956 identified those dates as one of the most severe drought periods in North Texas with the exception of the 1698 drought (Stahle and Cleaveland 1988:72).

Other potential damages detailed by private land owners and environmental professionals included disease, advancement of invasive species and the influx of people. Infestations of dutch elm disease killing elm trees and an unknown infection, a bug more than likely, drilling holes into live oaks worried one land owner. Advancement of trees such as cedars, mesquites and others onto the landscape previously more prairie like was described as potential threat. Relating to drought issues the utilization of water for non-native, or introduced, species of plants and trees concerned another land owner. Although no further details were given the belief could be because introduced vegetation requires more water in order to survive than native ones. Lastly, too many people moving to the area with overgrazing of cattle as a consequence of increased population and less acres available concerned some of the participants.

The oil and natural gas exploration and extraction activities make up the final environmental factor identified by the research participants. Five of the eleven participants did not give oil and natural activities as an environmental factor, however, those who did reply on the issue showed concern. Royalties from natural gas and other mineral rights extraction within and around the national grasslands lead to increased drilling activity in the region. One land owner expressed concern over this oil and gas activity wondering whether recent earthquakes, in an area not known for them, correlated with drilling of the Barnett Shale.

Changes to the natural environment occur with oil and natural gas drilling. Construction for well pads, access roads and pipeline routes displaces large number of trees and other vegetation. Through personal experience as an archaeologist working for various Cultural Resource Management (CRM) company pipelines and access roads often extend for many miles requiring the removal of any trees along a Right of Way (ROW). The large amounts of water required to drill the Barnett Shale was also a concern, and the waste water going back into the injection wells upon completion could potentially contaminate the water table. One land owner expressed concern over using potentially contaminated groundwater on plants. Finally when drilling is completed re-vegetation is required, however some environmental professionals do not like the drilling companies use of introduced grasses, such as KR bluestem, instead of native species in the seed mixes used for re-vegetation.

Past and Future Landscape Visualization

In order to understand how plants and trees have changed over time in the LBJ National Grasslands views on how the landscape appeared in the past according to the participants is an important aspect. Two of the four participants who completed the questionnaire noted the

landscape was the same or similar. As noted in the questionnaire one of the two participants developed his view through conversations with people who lived in the area for many years. The remaining land owners interviewed visualized the landscape as either forested or farmed, or a combination of both. Two of the land owners observed the area heavily forested or timberland. One of the two participants reflected that eventually forests changed into cotton fields. Growing cotton on forested land required clearing of the Western Cross Timbers woodlands, and the view that farming was prevalent in the past was expressed by two other participants. Another viewpoint from land owners stated that the landscape contained less underbrush and more land clearing, however for what purpose was not specified.

As expected the view of the environmental professionals followed an ecological analysis in assessing the use of the past landscape. Participant I commented on varying historical accounts describing the vegetation of the Western Cross Timbers vegetation as thick as keeping a hat on was difficult to as open to where a wagon would fit through. This description led the participant to consider widely variable scenery of post oak and blackjack oaks canopy with an herbaceous understory comprised of grass and flowers. The small branches of the post oaks when burned left a barrel like trunk and two or three thick branches above head level. Cedar trees on the other hand have the opposite effect by not returning to previously burned areas no matter how much time passes. As the area appears today grasslands covered what was not forested. Participants J and K envisioned tall grass prairies with scattered post oak forests before “we stuck the plow in the ground”. Gullies formed, sometimes from cattle trails, and by 1915 most of the farmers fled due to erosional gullies greatly reducing the annual cotton production.

The question of the LBJ National Grasslands in the future in terms of the environmental setting asked of the participants and environmental professionals provided varying results. Concerns over an extended drought and potential climate change persist with the hope that the effects will not be too severe. The largest percentage of participants, six, agreed that development is the future for all of Wise County. Farmers are selling their land to developers who in turn break the land up into 5 or 10 acre ranchettes that can be used as tax breaks if the new owners keep cattle on their property. The lack of mineral rights could also help land owners decide in the future to sell their land for subdivision. Three participants expressed erosion and overgrazing of the land most likely in the future. One reason given for the erosion and overgrazing includes improper cattle grazing practices on the growing number of 5 or 10 acre ranchettes. The land is not sustainable often for the number of cattle on the ranchettes, or ranchers fail to rotate the cattle in order for the grasses to return. Additionally, related to land use farming was predicted less productive due to drought conditions continuing into the future.

Other participants chose to describe scenarios for the future Wise County and LBJ National Grasslands based on how they plan to use or manage the land. One participant thought that no change would occur from the present but not elaborating any further. Utilizing the same acreage for cattle and wildlife, along with the clearing of more land for cattle grazing comprised another response. The promotion and harvest of another participant's coastal Bermuda and pecan trees on their own land was revealed by the questionnaire. Lastly, one of the environmental professionals wants to burn more land to maintain a large canopy cover within the Western Cross Timbers and manage cattle grazing.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

It is impossible to cover every aspect of how plants and trees have been affected over a long period from human landscape modification within this applied thesis research. What is attempted presently investigates some of the major factors with the available information online and from limited interviews. GIS data confirmed that land use changed the most between the years of 1992 and 2001, with only minor additional changes by 2006. The loss of acreage in watered areas was the most visible change by 2006. Urbanization increased greatly between 1992 and 2001 with more people moving into the Wise County, and in the LBJ National Grasslands along the county roads, farm to market roads and private roads. Because of human expansion into the LBJ National Grasslands the advancement of barren land with little or no vegetation, less cultivated land and an increase in grassland/herbaceous landscapes transpired.

Evaluating the environmental change earlier in time has to come from early firsthand accounts, archaeological evidence and ethnographic interviews with the local participants who, or their families have, lived in the area for many years. Interviews with the research participants and environmental professionals confirmed that a long history of cattle ranching has been a mainstay activity for the area, and continues into modern times. Previously agriculture dominated with cotton, wheat, watermelons and peanuts grown for both economic and personal purposes. The resulting action, along with active cattle grazing, often restricted the growth of native species of plants and trees. The Dust Bowl Era, along with erosion and soil nutrient removal from earlier improper farming practices greatly hurt the landscape leading to federal actions

attempting to restore the grasslands. Presently federal and state assistance helps land owners prevent erosion and manage their land so that cattle grazing can persist.

One last important aspect to examine is the overall environment, the plants, trees and the people living within it, further into the future. Predicting the landscape in the future through modeling often is more effective when based on multi-scales, integrated and spatially categorical aspects. Also more often the source of land use changes is because of economic opportunities by people (Veldkamp and Lambin 2001:1, Lambin, et al. 2001:261). As already confirmed by some of the research participants a concern is more people moving into the administrative boundary of the LBJ National Grasslands and Wise County. The question is what kind of condition the natural landscape will be in with increased population, more 5 to 10 acre ranchettes and the possibility of eroded, overgrazed grasslands due to improper cattle grazing practices on the ranchettes.

The formation of a predictive model of the LBJ National Grasslands (Figure 11), using "fuzzy logic" in ArcGIS, examined the following environmental characteristics: land use gridcode 71 (grasslands/herbaceous), the antler sand geologic formation, and human disturbance. The green area of the model represents where the GIS designated grasslands have the best potential to flourish in the future and support efficient cattle grazing. The red area depicts locations of human disturbance representing the lowest probability with a value of zero for grasslands or herbaceous locations. The decision to use the grasslands/herbaceous gridcode corresponded with the greatest acreage within the administrative boundary. The Antler sand geologic formation was used based on two factors: the greatest acreage and the widespread distribution. Human disturbance only looked at the most occupied areas within the administrative boundary,

namely along the US Highways and adjacent to the railroad system. The first is US Highway 380 following the southern border heading east to west and US Highway 81/287 roughly in the middle of the administrative boundary heading from the southeast to the northwest.

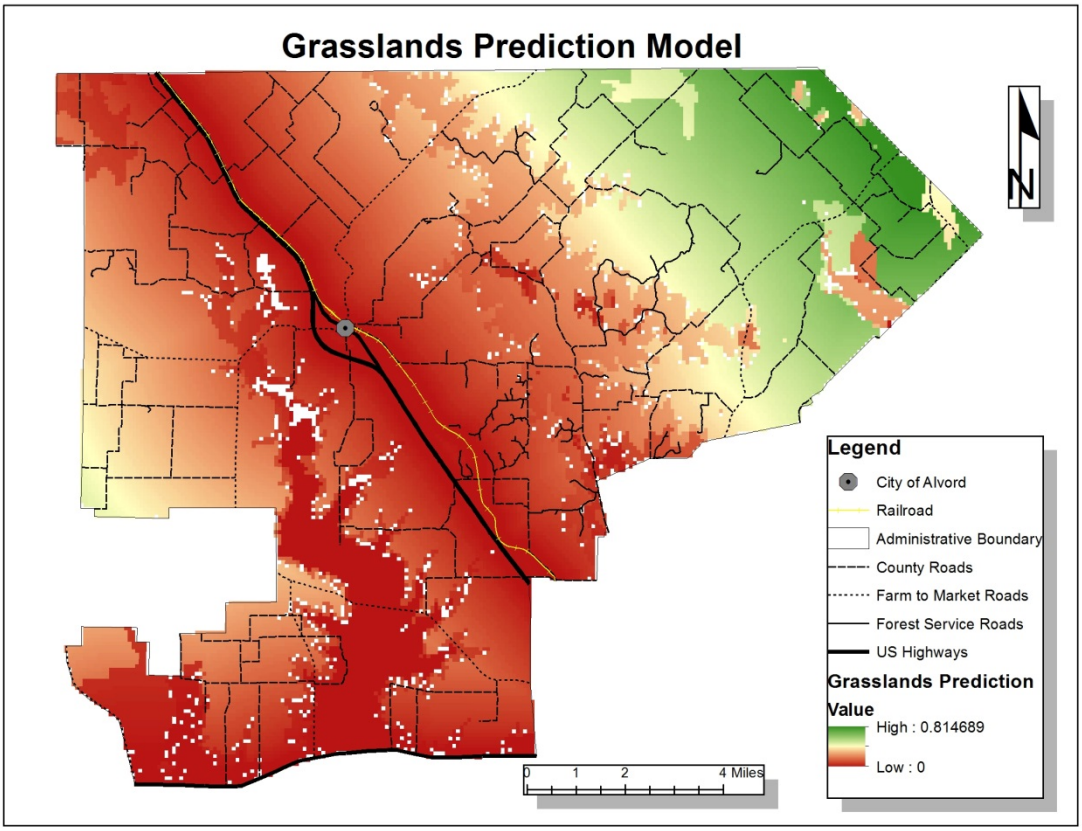

Figure 11. *Prediction Model for the Grasslands/Herbaceous Gridcode*

In addition to the major highways the railroad system contributes to human disturbance. The railroad system in Wise County and the LBJ National Grasslands parallels US Highway 81/287 traveling southeast to the northwest. According to Cates two different railroads traversed the research area, the Fort Worth and Denver City Railroad and the Chicago, Rock Island and Gulf Railroad (1907:357). The Fort Worth and Denver City Railway Company (FW&D) originally chartered in 1873 did not begin construction until 1881 due to the financial panic of 1873. Completion of the railroad to the Texas state line occurred in 1888. The FW&D Railroad

accelerated the growth of the area with the “No settlers, no trains” and using winter wheat as food for cattle promotions (Billingsley N.D.). The Chicago, Rock Island and Gulf Railway Company (CRI&G) chartered in 1902 constructed originally to extend the Rock Island system from Fort Worth to Galveston. A year later in 1903 the CRI&G merged with three other subsidiaries of the Rock Island to form a 334 mile system stretching from Oklahoma to Texas (Young N.D.).

Recommendations

Variations in land use management patterns between private land owners and environmental professionals sometimes lead to erosion of the landscape. The Smiley-Woodfin grasslands in North Texas with regard to the natural landscape provided an example of how the grasslands originally looked in an area surrounded by nearly 100 percent human disturbance. The grasslands have never been plowed since the mid-1800s when European settlers first started arriving in modern Texas. The man responsible for the conservation was M.L. Smiley (1872-1953) who recognized that the area lacked sufficient fuel sources and was too far away from a water source. Lands adjacent to the grasslands farmed in the past eroded because of depleted soil. Smiley originally used the land for cattle grazing and hay production and technologies such as cutting and drying using steam powered presses. The continual use of the Smiley-Woodfin prairie grasslands for hay production makes it the state’s largest supplier of native hay. (www.atlas.thc.state.tx.us/Lamar-county.htm Accessed 12-13-14).

Examining plants and trees in the research area modified through human interaction of the landscape in the present, along with historic and prehistoric sites in the past three recommendations are put forth:

- Adaptive and holistic cattle grazing plans for current and future land owners within the research area and surrounding Wise County

A location in North Central Texas currently offers potential model for conservation while operating as a working cattle and sheep ranch. The 2150 acre Bear Creek Ranch in Parker County presents an opportunity to view the tallgrass prairie grasslands as close to its original form as possible under the management of the Dixon Water Foundation. The foundation promotes healthy watersheds by implementing good landscape choices through sustainable land practices at four working ranches in North and West Texas, funding annual programs for ecosystems, providing education for landowners, and raising public awareness about healthy living and watersheds. The grazing plan used at Bear Creek and the other working ranches are adaptive and holistic. Any change in the environment is taken into account modifying the grazing plans, and every January a new plan developed (Board of the Dixon Water Foundation 2010).

The day-to-day operations at Bear Creek Ranch encompass rotating cattle and cross-bred sheep around four windmill fed water stations to maintain the native tallgrass prairie vegetation and conserve water. A total of 22 fenced paddocks are enclosed using barbed wire and electric fences around four water stations and Bear Creek. Cattle eat the native grasses including little bluestem, big bluestem, and indian grass, while the sheep eat the weeds. Allowing cattle only the top one third of the grass containing all the nutrients conserves the native grasses and when this occurs they are moved to the next paddock. The rotating schedule works, except in times of severe drought, and the duration of time in one paddock depends on the current conditions with two days common. The pasture area is not used again until the grasses grow back, thus preventing erosion. The design works but is more expensive than regular cattle grazing due to

the higher costs of spanning more barbed wire sections and electric fences. Additional time is likewise required by ranchers in monitoring each paddock to ensure that each is properly grazed and allowed to regrow (Personal communication with Danny Parker 4-23-13).

- Expansion of partnerships between governments agencies already in place and private land owners

In the LBJ National Grasslands and surrounding area an expanded partnership between government agencies and private land owners could improve land management practices. Land management practices like those at Bear Creek Ranch could reduce overgrazing of land on privately owned lands. The higher costs to start and maintain the process compared to normal cattle grazing on privately owned land points to an important issue to overcome. Also to be effective large numbers of acreage is necessary posing a problem with small ranchettes composed of usually no more than ten acres becoming more common. Control burns on grazing lands, as done in the 78 federal units, could further assist in natural landscape preservation by providing sufficient nutrients for cattle. The continued partnership with environmental professionals from the USDA and other government agencies and private land owners in the future probably provides the greatest opportunity to reduce erosion and other land issues. The infrastructure is already in place for the partnership and further education to continue into the future. Research into how to help the programs assist more land owners is the next avenue to examine with the expected rise in population in Wise County.

- Models using ArcGIS to predict where archaeological sites and vegetation changes within Wise County could be located by examining natural characteristics and man-made landscape changes

The location of archaeological sites depends on both natural and man-made environmental conditions along with the vegetation. Understanding site variation and their impact on the environment is important. Modification of the natural environment is often more common with historic sites compared to prehistoric sites. By overlaying identified site locations on top of the soils, geology and topography of an area, potentially undiscovered sites may be identified by examining land with similar characteristics. Vegetation change prediction offers similar results by examining the same environmental information but looking at individual plant species or diverse ecosystems instead of archaeology sites. Lastly, the overlay process could work in any location, not just the research area, as long as ArcGIS data is available.

CHAPTER VII

PERSONAL REFLECTION

Reflecting on the process of researching and writing this applied thesis I found I enjoyed learning new skills and improving on many others. A characteristic of myself is a lack of curiosity at times, however the subject pushed me to look deeper and investigate further to find pertinent information and discover connections resulting in the final analysis. Not having any experience with ArcGIS before starting the applied thesis required taking a class and many hours practicing and learning followed. In the end ArcGIS was extremely beneficial and is helpful for both recreational and professional work in the future. Gaining time management techniques between researching, writing, and working improved during the overall process. Working out of town as an archaeologist and living in hotels from a week to a month at one point proved to be a challenge. As time went on I learned how to better schedule interviews between my work schedule and work on the applied thesis at night in hotels.

In addition other personal improvements transpired helping to complete the applied thesis in a timely manner. Personality wise I am an introvert, not always a good trait when interviews are required. As my applied thesis progressed arranging and conducting interviews became easier over time. The harder part came transcribing the interviews due to hearing impairment as a disable veteran, but by using computer programs to slow down the recording speed, the problem was resolved. Overall I greatly enjoyed the applied thesis subject, the process, and the skills gained will directly benefit me in the future.

APPENDIX A

DYKSTERHUIS PLANT AND TREE TYPES

Dyksterhuis Plant and Tree Types					
Scientific Name	Common Name	Quercus-Smilax Percent	Quercus-Prosopis Percent	Prosopis Percent	Old Field Percent
Agropyron smithii	Western wheatgrass	-	0.2	-	-
Ambrosia psilostachya	Western or cuman ragweed	1.1	1.2	1.6	6.8
Andropogon sachareides	Silver beardgrass	0.9	0.6	1.9	2.8
Andropogon scoparius	Beardgrass/Little bigstem	1.2	1.4	1.1	0.2
Andropogon ternarius	Splitseed bluestem	-	-	-	0.6
Annual forbs	Various	19.5	19.8	12	18.2
Arista spp (annuals)	Threeawns	3.3	1.2	0.4	37
Arista spp (perennial)	Threeawns	1.1	6.6	4.3	1.7
Bouteloua curtipendula	Sideoats grama	3.7	2.1	3.9	0.3
Bouteloua gracilis	Blue grama	-	0.3	0.4	-
Bouteloua hirsuta	Hairy grama	2.7	2.8	3.8	0.8
Bouteloua rigidiseta	Texas grama	-	0.5	0.8	-
Bromus spp (annual)	Brome grass	1.6	4.6	1.4	0.2
Buchloe dactyloides	Buffalo grass	2.3	12	20.6	0.4
Bumelia lanuginosa	Chittamwood	0.4	0.2	-	-
Carex spp	Sedge	1.2	1.4	-	-
Chloris verticillata	Tumble windmill grass	3	0.6	1.1	2
Celtis spp	Hackberry	-	0.2	-	-

Cenchrus pauciflorus	Coastal sandbur	0.2	-	-	2.5
Condalia obtusifolia	Condalia obtusifolia	-	-	0.2	-
Cornus asperifolia	Eastern roughleaf	0.2	0.2	-	-
Crataegus spp	Hawthorne	0.4	-	-	-
Cynodon dactylon	Bermuda grass	0.4	2.7	-	3.7
Elymus canadensis	Canada wildrye	-	1.1	-	-
Eragrostis spp (perennial)	Love grass	2.9	2.1	0.9	2.1
Festuca octoflora	Walter	2.4	4.9	4.3	5.8
Hordeum pusillum	Little Barley	-	4.3	14.1	3.1
Leptoloma cognatum	Fall witchgrass	-	0.6	1.7	1.1
Manisuris cylindrica	Michx	0.2	-	-	-
Muhlenbergia reverchoni	Seep muhly	-	0.2	-	-
Opuntia leptocaulis	Cholla/Christmas cholla	-	-	0.5	-
Opuntia spp (flat-stemmed)	Prickly pear	-	0.3	2	-
Panicum obtusum	Vine mesquite	-	-	0.3	-
Panicum scribnerianum	Scribner's panic grass	1.8	0.4	0.2	0.2
Paspalum ciliatifolium	Hairy lens grass	6.4	2.7	1.1	3.1
Perennial forbs except Ambrosia	Various	1.6	1.6	3.7	2
Poa arachnifera	Texas bluegrass	-	0.5	-	-
Prosopis juliflora	Mesquite	-	0.5	3.4	-

Continued on next page

Dyksterhuis Plant and Tree Types					
Scientific Name	Common Name	Quercus-Smilax Percent	Quercus-Prosopis Percent	Prosopis Percent	Old Field Percent
Rhus glabra	Smooth sumac	0.2	-	-	-
Rhus trilobata	Skunkbush sumac	-	2.4	-	-
Schedonnardus paniculatus	Tumblegrass	1.9	0.6	3.9	0.5
Smilax bona-nox	Saw greenbriar	10.4	2	-	3.7
Sporobolus asper	Tall dropseed	-	1.1	0.9	-
Sporobolus cyrptandrus	Sand dropseed	-	-	0.5	-
Stipa leucotricha	Texas winter grass	3.6	3.2	8.3	-
Symphoricarpos orbiculatus	Coralberry	0.2	-	-	-
Triodia flava	Tall redtop	0.2	-	-	-
Triodia pilosa	Buckley	-	0.3	0.2	-
Ulmus crassifolia	Cedar elm	-	0.5	0.2	-
Quercus stellata and marilandica	Post oak and Blackjack oak	25.8	11.7	-	0.4
All others	Various	0.2	0.4	0.3	0.8

APPENDIX B

BLAIR PLANT AND TREE TYPES

Blair Plant and Tree Types			
Scientific Name	Common Name	Texan	Kansan
Agropyron smithii	Western wheatgrass	X	
Andropogon furcatus	Beardgrass (bluestem)		X
Andropogon saccharoides	Silver beardgrass	X	X
Andropogon scoparius	Beardgrass (Little bluestem)	X	X
Arista spp	Threeawns		X
Bouteloua curtiperdula	Sideoats grama		X
Bouteloua hirsuta	Hairy grama		X
Bouteloua gracilis	Blue grama		X
Bouteloua racemosa	Grama		X
Carya buckleyi	Hickory	X	
Gaillardia puchella	Gaillardia		X
Gutierrezia texana	Broomweed		X
Stipa leucotricha	Texas wintergrass	X	
Triodia pilosa	Buckley	X	
Quercus stellata	Post oak	X	
Quercus marilandica	Blackjack oak	X	

APPENDIX C

ORZELL GRASSLAND FORB AND WOODY SPECIES

Orzell Grassland Forb and Woody Species			
Scientific Name	Common Name	Forb	Woody
Acacia angustissima	Prairie clover		X
Ambrosia psilostachya	Cuman ragweed	X	
Andropogon gerardii	Big bluestem	X	
Arista oligantha	Oldfield or prairie threeawn	X	
Arista purpurea	Purple threeawn	X	
Asclepias aspercula	Milkweed	X	
Berlandiera texana	Texas greeneyes	X	
Bothriochloa ischaemum	Yellow bluestem	X	
Bothriochloa saccharioides	Silver bluestem	X	
Bouteloua curtipendula	Sideoats grama	X	
Bouteloua hirsuta	Hairy grama	X	
Bouteloua rigidiseta	Texas grama	X	
Bumelia lanuginosa	Chittamwood		X
Carex microdonta	Littletooth sedge	X	
Carex planostachya	Cedar sedge	X	
Celtis laevigata	Sugarberry		X
Centarium bayrichii	Mountain pink	X	
Chasmanthium sessilifolium	Longleaf woodoats	X	
Cornus drummondii	Roughleaf dogwood		X
Cornus florida	Flowering dogwood		X
Croton monanthogynus	Prairie tea	X	

Dalea aurea	Golden dalea	X	
Dalea compacta var. pubescens	Compact prairie clover	X	
Dalea frutescens	Black dalea	X	
Dalea multiflora	Roundhead prairie clover	X	
Dalea tenius	Prairie clover	X	
Desmanthus illinoensis	Illinois bundleflower	X	
Dyssodia tagetoides	False dogfennel	X	
Eragrostis sessilispica	Tumble lovegrass	X	
Eriogonum longifolium	Longleaf buckwheat	X	
Eryngium leavenworthii	Leavenworth's eryngo	X	
Evax prolifera	Bighead pygmyeuweed	X	
Evolvulus pilosus	Bluedaze	X	
Fimbristylis puberula	Hairy fimbry	X	
Gaillardia aestivalis	Lanceleaf blanket flower	X	
Grindelia squarrosa	Curlycup gumweed	X	
Gutierrezia dracuncuioides	Broomweed	X	
Hedoma drummondii	Drummonds false pennyroyal	X	
Hedyotis nigricans	Diamond heliotype	X	
Heliotropium tenellum	Pasture heliotype	X	
Juniperus virginiana	Eastern redcedar		X

Continued on next page

Orzell Grassland Forb and Woody Species			
Scientific Name	Common Name	Forb	Woody
Krameria lanceolata	Trailing krameria	X	
Liatris mucronata	Cusp gayflower	X	
Lythrum alatum	Winged lythrum	X	
Marshallia caespitosa	Puffyballs	X	
Mentzelia oligosperma	Chickenthief	X	
Mirabilis alba	Mirabilis alba	X	
Monarda citriodora	Lemon beebalm	X	
Palafoxia callosa	Small palafox	X	
Paronychia virginica scopa	Yellow nailwort	X	
Pediomelum linearifolium	Narrowleaf indian broadroot	X	
Phyllanthus polygonoides	Smartweed leaf-flowers	X	
Polygala alba	White milkwort	X	
Quercus buckleyi	Texas red oak		X
Quercus fusiformis	Texas live oak		X
Quercus marilandica	Blackjack oak		X
Quercus shumardii	Shumard red oak		X
Quercus stellata	Post oak		X
Ratibida columnaris	Upright prairie cornflower	X	
Rhus aromatica	Fragrant sumac		X
Rhus glabara	Smooth sumac		X
Rhus radicana	Poison ivy		X

Rhus toxicodendron			X
Salvia azurea	Pitcher sage	X	
Schizachyrium scoparium	Little bluestem	X	
Scutelaria wrightii	Wright's skullcrop	X	
Senna roemeriana	Twoleaf senna	X	
Silphium laciniatum	Compass plant	X	
Smilax bona-nox	Saw greenbrier		X
Stenosiphon linifollus	False garra	X	
Styllingia texana	Texas toothleaf	X	
Symphoricarpos orbiculatus	Coralberry		X
Thelesperma filifolium	Stiff greenthread	X	
Tomanthera densiflora	Tomanthera densiflora	X	
Tragia urticifolla	Nettleleaf noseburn	X	
Ulmus crassifolia	Cedar elm		X
Verbena bipinnatifida	Purple prairie verbena	X	
Viburnum rufidulum	Rusty blackhaw		X

APPENDIX D

DIGGS ET AL. PLANT AND TREE TYPES

Diggs et al. Plant and Tree Types		
Scientific Name	Common Name	Cross Timbers
Bouteloua curtiperdula	Sideoats grama	X
Bouteloua hirsuta	Hairy grama	X
Carya illinoinensis	Pecan	X
Celtis spp	Hackberry	X
Elymus canadensis	Canada wildrye	X
Juniperus spp	Juniper	X
Panicum virgatum	Switch grass	X
Prosopis glandulosa	Honey mesquite	X
Quercus marilandica	Blackjack oak	X
Quercus stellata	Post oak	X
Sporobolus asper	Tall dropseed	X
Stipa leucotricha	Texas winter grass	X
Ulmus crassifolia	Cedar elm	X

APPENDIX E

PARTICIPANT INTERVIEW QUESTIONS

Interview Questions

1. What is your name?

2. How long have you or your family lived here?

3. How much acres of land do you own within the administrative boundaries of the LBJ National Grasslands?

4. How do you use the land and has this changed any from the past?

5. If the land has been modified (terraced, cleared, mined or quarried, etc.) under your ownership what was the purpose for the change? Do you know how the land was modified in the past?

6. For private land owners and Grassland employees, what kind of soil is present on your land, such as sandy loams or clays? If bedrock is present how far below the surface on average is it located?

7. How has controlled burns been used by yourself or to your knowledge in the past? If not employed how long has the area been controlled burn free to the best of your knowledge?

8. Do you use chemicals or organic methods to maintain soil fertility, and why?

9. How do you perceive the land changes, or how would you classify any landscape changes, manmade or natural

10. What types of plants and trees (that you are able to identify) are present now, and if different from the past how?

11. What plants and trees do you consider to be native, and the same for exotic?

12. What other factors exist that could benefit or harm the plant and tree species? (climate change, drought conditions, etc.)
13. When you look at the land in its current state how do you visualize the landscape in the past?
14. How do you envision the use and appearance of the landscape in the future? What are your reasons for this belief (climate, population growth, oil and natural gas drilling, etc.)?
15. Based on the past land use and present plant and tree species what kind of predictive model can be determined for the future? Is the idea even feasible?

APPENDIX F

LOCAL FEED STORE PARTICIPANT QUESTIONAIRRIE

Local Feed Store Participant Questionnaire

1. How many acres do you or your family own, how long have you lived there, and what is the closest city?
2. How do you use the land and how has this changed from the past?
3. Has the landscape been modified in the past or present (terraced, cleared, quarried, etc) And if so for what purpose?
4. What kind of soil do you have (loams, clays) and if bedrock is present how deep below the surface is it?
5. Have control burns been employed in the past or present, and if so for what purpose?
6. Do you use chemicals or organic methods to maintain soil fertility and why?
7. What types of plants and trees are present now, and if different from the past ho

APPENDIX G

SOILS ASSOCIATED WITH EACH SOIL GROUPING

Loams	
Designation	Description
AnC	Anocon loam, 2-5% slopes
Ar	Arents, loamy
BdB	Bastsil loamy fine sand, 0-3% slopes
BfB	Bastsil fine sandy loam, 0-3% slopes
BtC	Bonti fine sandy loam, 2-5% slopes
BxC	Bonti-Exray complex, stony, 1-8% slopes
ByE	Brackett-Aledo complex, 5-20% slopes
ChB	Chaney loamy fine sand, 1-4% slopes
CoB	Cisco loamy sand, 1-3% slopes
DfC	Duffau loamy fine sand, 1-5% slopes
DuB	Duffau fine sandy loam, 1-3% slopes
HaB	Hassee fine sandy loam, 0-2% slopes
KtC	Keeter very fine sandy loam, 1-6% slopes
LnB	Lindy loam, 1-3% slopes
MaB	May fine sandy loam, 0-2% slopes
NdB	Nimrod fine sand, 1-4% slopes
PhC	Patilo-Heaton fine sands, 3-12% slopes
SdB	Selden loamy fine sand, 1-3% slopes
SfC	Silawa fine sandy loam, 3-8% slopes

SoC	Somervell-Aledo complex, 1-8% slopes
TuB	Truce fine sandy loam, 1-3% slopes
TuC	Truce fine sandy loam, 3-5% slopes
VeB	Venus loam, 1-3% slopes
VeC	Venus loam, 3-8% slopes
WeC	Weatherford-Duffau complex, 3-8% slopes
Eroded Loams	
KtC3	Keeter very fine sandy loam, eroded, 3-6% slopes
SfC3	Silawa fine sandy loam, eroded, 3-8% slopes
TuC3	Truce fine sandy loam, eroded, 2-5% slopes
WeC3	Weatherford-Duffau complex, eroded, 3-8% slopes
WtC4	Windthorst fine sandy loam, eroded, 2-6% slopes
Gullied Soils	
DvC4	Duffau-Gullied land complex, 3-8% slopes
Flooded Loams	
Ba	Balsora silt loam, occasionally flooded
Bb	Balsora silt loam, frequently flooded
Ps	Pulexas very fine sandy loam, 83ccasionally flooded
Pu	Pulexas soils, frequently flooded
Continued on next page	

Stony Loams	
Designation	Description
CsE	Cona very stony sandy loam, 3-12% slopes
HeB	Hensley very stony loam, 1-3% slopes
Clays	
BkB	Blanket clay loam, 1-3% slopes
BoB	Bolar clay loam, 1-3% slopes
BoC	Bolar clay loam, 3-5% slopes
MoB	Mingo silty clay loam, 1-3% slopes
PrB	Ponder clay loam, 1-3% slopes
PvB	Purves clay, 1-3% slopes
SaB	Sanger clay, 1-3% slopes
SaC	Sanger clay, 3-5% slopes
SbB	San Saba clay, 1-3% slopes
SpB	Speck clay loam, 0-2% slopes
VrC	Vernon clay, 3-8% slopes
WzC	Wise clay loam, 3-8% slopes
Flooded Clays	
Bc	Balsora silty clay, frequently flooded
De	Deleon silty clay, frequently flooded
Fr	Frio silty clay loam, occasionally flooded
Stony Clays	
OwE	Owens very stony clay, 8-30% slopes

PaC	Palopinto extremely stoney clay loam, 1-8% slopes
Quarry Soil	
Po	Pits or quarries

APPENDIX H

NLCD LAND USE GRIDCODES

NLCD Land Use Gridcodes				
Description	Grid Code	1992 Acres	2001 Acres	2006 Acres
Open Waters	11	1432.38	947.5	790.8
Low Intensity Residential	21	415.42	X	X
Open Spaced Development	21	X	6415.85	6417.13
High Intensity Residential	22	3.72	X	X
Low Intensity Developed	22	X	1603.39	1611.25
Commercial/Industrial	23	203.13	X	X
Medium Intensity Developed	23	X	382.6	382.6
High Intensity Developed	24	X	29.34	29.34
Barren Land	31	88.13	683.6	767.58
Quarries/Strip Mines	32	606.44	X	X
Deciduous Forest	41	19608.26	24640.18	24428.59
Evergreen Forest	42	2580.25	206.55	204.55
Mixed Forest	43	851.83	X	X
Shrubland	51	6017.75	X	X
Shrub/Scrub	52	X	7.34	7.34
Grasslands/Herbaceous	71	43903.96	61754.72	61946.47
Pasture/Hay	81	30465.98	14062.23	14035.19
Row/Cultivated Crops	82	7706.5	4587.24	4625.79
Small Grains	83	1124.72	X	X
Urban/recreational Grasses	85	80.81	X	X

Woody Wetlands	90	X	X	70.2
Emergent Herb Wetlands	92	225.52	X	X
Emergent Herb Wetlands	95	X	2.21	7.89

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