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16. Abstract

The environmental risks associated with the use of seven herbicides and three insecticides comprising a portion of the Texas Department of Transportation's roadside pest management program were assessed. The materials were classified as EPA Category 3 or 4, signifying minimal toxicity. Although the chemicals used may pose a threat to environmental components in some situations, the manner in which they are used combined with the small roadside area treated mitigates the effects and treatment such that the risk is insignificant. This document contains recommendations including guidelines and mitigation measures for mechanical, chemical, cultural, and biological methods for TxDOT's use in developing an integrated pest management program.

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FINAL
ENVIRONMENTAL IMPACT STATEMENT: ROADSIDE PEST MANAGEMENT PROGRAM, VOLUME 2

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Research Report 1933-3F, Volume 2
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Research Study Title: Environmental Concerns in Maintenance: A Proactive Initiative

Sponsored by the
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IMPLEMENTATION STATEMENT

This report is an assessment of the Roadside Pest Management Program for the Texas Department of Transportation (TxDOT) and its impacts on the environment in the vicinity of the highway corridor. The findings are used to evaluate five program alternatives formulated for the purpose of this study. The results from this study are expected to enhance TxDOT policies and procedures for systematically incorporating environmental concerns into the planning and operational phases of roadside maintenance.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes.

ACKNOWLEDGMENTS

This report and the attendant public hearings continue the scoping effort toward the development of a final Environmental Impact Statement concerning the Roadside Pest Management Program for the Texas Department of Transportation. The authors gratefully acknowledge the interest shown by and participation of individuals, citizens' groups, and government agencies who offered their appraisal of the impacts of roadside pest management on the environment. The input received to date has been invaluable in establishing research study parameters.

The Design Division of TxDOT furnished a list of individuals, groups, and agencies concerned with the impacts of highways on the environment.

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List of Abbreviations

BMP - best management practice
Caltrans - California Department of Transportation
DEIS - draft environmental impact statement
EIS - environmental impact statement
EPA - Environmental Protection Agency
FEIS - final environmental impact statement
IMS - TxDOT's Insect Management System
IVM - integrated vegetation management
IPM - integrated pest management
MTO - mower-thrown object
MOU - memorandum of understanding
MSA - metropolition statistical area
NPDES - National Pollutant Discharge Elimination System
PMP - TxDOT's pest management program
RMP - Roadside Management Plan
ROW - right-of-way
TDA - Texas Department of Agriculture
TPWD - Texas Parks and Wildlife Department
TWC - Texas Water Commission
TNRCC - Texas Natural Resource Conservation Commission
TTI - Texas Transportation Institute
TxDOT - Texas Department of Transportation
USFS - United States Forest Service
USFWS - United States Fish and Wildlife Service
VMS - TxDOT's Vegetation Management System
WSDOT - Washington State Department of Transportation

Appendix A - Chapter 1

Draft EIS

Pest Management Program

Appendix A - Chapter One

Assessment By Vegetational Region

1.0 Introduction

Texas is one of the most diverse regions of North America in terms of environment and vegetation, with a climate ranging from humid to arid (Thornthwaite, 1931). Moisture, temperature, soils and geology vary greatly across the state. Vegetation types range from dense mixed-species forests in eastern regions to sparse desert scrub in drier western regions.

1.1 Stratification by Vegetational Region

The interaction of climate over Texas and the area soil groupings combine to form ten areas of similar natural vegetation (natural regions). These natural regions (See Figure 3-1 on p.58) were defined by Gould, Hoffman and Rechenthin (1960), and form the basis for vegetation management as set forth in a TxDOT manual (1993).

(1) Pineywoods
(2) Gulf Prairies and Marshes
(3) Post Oak Savannah
(4) Blackland Prairies
(5) Cross Timbers
(6) South Texas Plains
(7) Edwards Plateau
(8) Rolling Plains
(9) High Plains
(10) Trans-Pecos

Physiographic provinces are broad divisions of relatively homogeneous area in terms of geology and climate, which give rise to similar soil and vegetation types.

The use of vegetation regions reduces the complexity in describing the environmental and biologic diversity found in Texas into manageable proportions.

The environmental consequences of alternative roadside pest management practices can be evaluated and discussed more effectively region by region than if presented for the entire state highway system as a whole. The management of roadside vegetation in Texas may vary considerably among regions, but the treatments prescribed usually within a region remain reasonably similar. As shown in Volume 1, a TxDOT district could impinge on two or more vegetation regions. For each highway district, because of the variation in regional environmental conditions, there often could be more than one set of issues, approaches, and methods identified with a specific vegetation management operation.

The general geologic, hydrologic, soil, and climatic features, along with the broad vegetational patterns for each of the ten vegetation regions through which Texas state highways traverse, are detailed throughout Appendix A.

1.2 Topography and General Descriptions of the Regions

The topography within Texas is highly variable. It ranges from the nearly level coastal basins and plains to stony plains with hilly divides to canyons and basins and plateaus.

The Pineywoods lie within the Gulf Coastal Plains, which extend 121-201 km(75-125 miles) into Texas west from the Louisiana border. This natural region encompasses 15.80 million acres, including portions of TxDOT Districts Atlanta, Beaumont, Houston, Lufkin, and Tyler. The Pineywoods area is a gently to strongly sloping dissected coastal plain. Elevation ranges from 61-213 m, (200-700 ft) increasing from south to north. The average annual precipitation is 1016-1422 mm, (40-56 in) increasing from northwest to southeast. Rainfall tends to be distributed evenly throughout the year. The frost-free period ranges from 235-265 days, increasing from north to south. Average annual temperature is 18-20 °C (64-68 °F). Timber production is the region's dominant land use, comprising 50-75 percent of the land area. Secondary uses include forest grazing, tame pasture, and the production of feed grains, forages, fruits, and vegetables. The primary livestock use is the cow-calf operation. Reservoirs offer recreation, including fishing, hunting, and swimming. The area encompasses the Beaumont-Port Arthur-Orange, Houston, Longview-Marshall, and Texarkana metropolitan statistical areas (MSAs).

The Gulf Marshes, comprised of a narrow strip of lowlands adjacent to the coast and barrier islands which extend from Mexico to Louisiana, total approximately 202,350 ha (500,000 ac). The Gulf Prairies include the nearly level plain extending 48-129 km (30-80 m) inland from the Gulf Marshes, and include approximately 3.6 million ha (9 million ac). The combined acreage is approximately 4 million ha (10 million ac). It includes portions of TxDOT Districts Beaumont, Corpus Christi, Houston, Pharr, and Yoakum. The Gulf Marshes include low-lying coastal areas frequently covered with saline water, and vary from sea level to a few feet in elevation. The Gulf Prairies are nearly level, largely undissected plains from sea level to an elevation of 76 m (250 ft). Surface drainage is slow. The average annual precipitation is 610-1422 mm (24-56 in), increasing southwest to northeast. Rainfall peaks in September, with a secondary peak in May. The frost-free period ranges from 245-320 days, increasing from north to south. Average annual temperature is 20-23 °C (68-74 °F), increasing from north to south. The Gulf Prairies and Marshes provide wildlife production and recreation in low-lying areas, and support crops and livestock operations on the upland areas. Urban, industrial, and recreational developments have increased in recent years. The Houston-Galveston-Brazoria, Galveston-Texas City, Victoria, Brownsville-Harlingen, Beaumont-Port Arthur-Orange, and Corpus Christi MSAs lie within this region. This region of Texas has seen the greatest industrial expansion in history since World War II, primarily in the petrochemical industry. Other increasing development includes naval and agricultural operations.

The Post Oak Savannah lies to the west of the Pineywoods region and intermixes with portions of the Blackland Prairies in the south. The area includes the entire Claypan Land Resource Area of Texas, part of the Gulf Coastal Plains. This region encompasses approximately 2.77 million ha (6.85 million ac). It includes portions of TxDOT Districts Atlanta, Austin, Bryan, Houston, San Antonio, Tyler, and Yoakum. The Post Oak Savannah is characterized by gently rolling and moderately dissected wooded plains. Elevation ranges from 91-244 m (300-800 feet). The average annual precipitation is 762-1143mm (30-45 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 235-280 days, increasing from north to south. Average annual temperature is 18-21 °C (64-70 °F). The Post Oak Savannah is largely a farming and ranching region. The area supports grain crops, cotton, vegetables, and fruit trees. Pasture land for cattle is composed of native or improved grasses, or noncommercial oak forests. The area contains the Bryan-College Station, and Tyler MSAs.

The Blackland Prairies area intermingles considerably with the Post Oak Savannah to the southeast. The San Antonio and Fayette prairies are isolated southern extensions of the true prairie which runs from Texas to Canada, to the west of the Pineywoods region. This natural region encompasses approximately 5.1 million ha (12.6 million ac). It includes portions of TxDOT Districts Austin, Bryan, Dallas, Paris, San Antonio, Tyler, Waco, and Yoakum. The Blackland Prairie is characterized as a rolling and well-dissected prairie. Elevation ranges from 76-213 m (250-700 ft). The average annual precipitation is 762-1143 mm (30-45 in), increasing from northwest to southeast. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 230-280 days, increasing from north to south. Average annual temperature is 18-21 °C (64-70 °F). The Blackland Prairie is used primarily for cropland and livestock operations. Livestock uses are largely cow-calf and steer operations. Small remnants of native vegetation exist for grazing or native hay production. The Dallas-Fort Worth, Waco, and Killeen-Temple MSAs are found in this region.

The Cross Timbers and Prairies area is located in north central Texas and includes the Cross Timbers, Grand Prairie, and North Central Prairies land resource areas. The area occupies the southern portion of the Central Lowlands and the western extreme of the Coastal Plains. This natural region encompasses approximately 6.2 million ha (15.3 million ac). It includes portions of TxDOT Districts Austin, Brownwood, Dallas, Fort Worth, Waco, and Wichita Falls. The Cross Timbers and Prairies region is characterized by its gently rolling landform. Elevation ranges from 152-457 m (500-1,500 ft) above sea level. The annual average precipitation is 635-889 mm (25-35 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 230-280 days, increasing from north to south. Average annual temperature is 18-20 °C (64-68 °F). Almost 75 percent of the Cross Timbers and Prairies vegetational area serves as range and pasture. Cow-calf operations are the predominant livestock activity, with secondary dairy operations. Sheep and goat operations are found in the southeastern parts of the region. The Dallas-Fort Worth, Austin, Killeen-Temple, and Wichita Falls MSAs are located in this region.

The South Texas Plains lie south of a line drawn from San Antonio to Del Rio. The area lies in the western portion of the Gulf Coastal Plains and merges with the Mexico Plains to the west and southwest. The South Texas Plains region encompasses approximately 8.5 million ha (20.9 million ac). It includes portions of TxDOT Districts Corpus Christi, Pharr, San Antonio, and Yaokum. The South Texas Plains are characterized by a nearly level to rolling landform. The area is slightly to moderately dissected by intermittent drainage ways. Elevation ranges from sea level to 305 m (1,000 ft). The average annual precipitation is 457-762 mm (18-30 in), increasing from west to east. Rainfall peaks in September, with a secondary peak in May. The frost-free period ranges from 260-340 days, increasing from north to south. Average annual temperature is 21-23 °C (70-74 °F). Most of the northern portion of the South Texas Plains is rangeland for beef cattle and wildlife grazing. The southern portion supports cultivation of fruit, vegetables, grain, and cotton crops. Hunting leases are increasingly important to the region. The San Antonio, Brownsville-Harlingen, McAllen-Edinburg-Mission and Laredo MSAs lie within the region.

The Edwards Plateau encompasses what is known as the Texas Hill Country. This region includes the Granitic Central Basin in Llano and Mason Counties. The area is located just north of the South Texas Plains, and is bounded geographically on the east and south by the Balcones Escarpment. This region includes approximately 10.3 million ha (25.45 million ac). It includes portions of TxDOT Districts Abilene, Austin, Brownwood, Odessa, Pharr, San Angelo, and San Antonio. The Edwards Plateau is characterized as a deeply dissected, stony plain with broad and flat to undulating and hilly divides. Hilltops frequently are flat, with surrounded stair-stepped slopes. Elevation ranges from 366-914 m (1,200-3,000 ft) above sea level. The average annual precipitation is 305-813 mm (12-32 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 220-260 days, increasing from north to south. Average annual temperature is 18-21 °C (65-70 °F). Most of the Edwards Plateau is used as rangeland for mixed livestock (combinations of cattle, sheep, and goats) and wildlife. The region is the primary wool- and mohair-producing region in the United States, producing as much as 98 percent of the nation's mohair. Commercial hunting leases are increasing in regional importance. The agricultural operations in the area produce food and fiber crops such as sorghum, peanuts, plums, and peaches. Pecan orchards are located on flood plains. The area contains the Austin, San Angelo, and Midland-Odessa MSAs.

The Rolling Plains area is located in northern Texas between the High Plains and the Cross Timbers and Prairies. It coincides with the Rolling Plains land resource area of the Central Lowlands. This region encompasses a land area of approximately 9.7 million ha (24 million ac). It includes portions of TxDOT Districts Abilene, Amarillo, Brownwood, San Angelo, and Witchita Falls. The Rolling Plains area is characterized by a well-dissected, nearly level to rolling plain. Elevation ranges from 305-914 m (1,000-3,000 ft), however, few of the larger valleys fall substantially below the level of the plain. The average annual precipitation is 457-711 mm (18-28 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 185-235 days, increasing from north to south. Average annual temperature is 13-19 °C (56-66 °F). More than 75 percent of the area is rangeland used for cattle. Cotton, grains, and supplemental forages are important crops. The region supports the Abilene, Wichita Falls, and San Angelo MSAs.

The High Plains area is part of the Southern Great Plains which extend into north Texas. The Llano Estacado Escarpment divides the High Plains from the Rolling Plains immediately to the east. The region is dissected by the Canadian River Breaks in the northern part. The High Plains area encompasses approximately 7.9 million ha (19.4 million ac). It includes portions of TxDOT Districts Abilene, Amarillo, Childress, Lubbock, and Odessa. The High Plains area is a relatively level plateau which contains two canyons of note, Tule and Palo Duro, along the Caprock Escarpment. Many shallow depressions, or playa lakes exist, which are intermittent in nature and may contain several feet of water and cover as many as 16 ha (40 ac) after heavy rains (TPWD, 1982). The elevation ranges from 914-1372 m (3,000-4,500 ft). The average annual precipitation is 356-533 mm (14-21 in), increasing from southwest to northeast. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 180-220 days, increasing from north to south. Average annual temperature is 13-18 °C (56-64 °F). About 60 percent of the area is in cropland, half of which is irrigated. Cotton, vegetables, and grains are major crops. Rangeland comprises much of the remaining 40 percent of the area. Stocker operations are common. The Amarillo, Lubbock, and Midland-Odessa MSAs are located in this region.

The Trans-Pecos region is located in the western extreme of Texas and contains approximately 7.26 million ha (17.95 million ac). The eastern chain of the Rocky

Mountains extends into the Basin and Range Province. It includes portions of TxDOT Districts El Paso and Odessa. The Trans-Pecos region is characterized by mountain ranges, rough, rocky land, and flat basins and plateaus. Elevation ranges from 762-2667 m (2,500-8,751 ft), and includes Guadalupe Peak, the highest point in Texas. The region includes the Guadalupe Mountains, Chisos Mountains, and Davis Mountains, in addition to others. Notable canyons occur along the Big Bend of the Rio Grande and in the Guadalupe Mountains. The average annual precipitation is 203-457 mm (8-18 in), increasing from west to east and from low to higher elevations. Rainfall peaks in the period from July through September, with a secondary peak in November. The frost-free period ranges from 220-245 days, increasing from north to south. Average annual temperature is 14-21 °C (58-70 °F), increasing from northeast to southwest and from lower to higher elevations. More than 95 percent of the Trans-Pecos region remains as rangeland. The area is sparsely populated. Most ranching operations stock cattle and/or sheep, although some wildlife is managed for hunting purposes. Irrigated crops such as cotton and grains, and some vegetables grow along the Rio Grande. The region's MSA is El Paso.

2.0 Environmental Consequences of Treatments on Topography

Proposed ROW pest management treatments for TxDOT highways would have no effect on macrotopography, although original highway construction modified the local topography to some extent. The only potential treatment effect on microtopography is mass soil movement that may be initiated by saturated soils and non-cohesive slopes following large-scale vegetation removal. With the use of best management practices in vegetation management, however, mass soil movement resulting in changes in microtopography is minimized.

Appendix A - Chapter 2

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Pest Management Program

1.0 Introduction

Geology and soils can be important physical factors in determining slope stability, shoulder drainage, surface erosion, and water quality along Texas highways. Geology often directly influences ROW slope stability. Slope failures, in turn, could affect water quality and, in more severe cases, impact the physical condition of the highway. The relationship between geology, soils, and vegetation on highway ROWs is also extremely important. Good vegetative cover protects the function, stability, and condition of soils, while good soil conditions have been designated as healthy vegetative cover. Thus, both the physical and biological roadside environment must be evaluated when developing and applying pest management techniques.

Physiographic provinces are broad divisions of relatively homogeneous area in terms of geology and climate, which give rise to similar soil and vegetation types. Four major physiographic provinces meet in Texas. These have been designated as the Gulf Coastal Plain, the Great Central Lowlands, the Great Plains, and the Basin and Range Provinces. Elevations generally range from sea level along the Gulf Coast and gradually increase northwestward to more than 1,372 meters (4,500 feet) in northwestern Texas (Hatch et al, 1990).

1.1 Geology and Soils

The wide variety of present land forms over Texas, extending from the Gulf of Mexico to the mountains and plains of northwestern Texas, points to a complicated series of volcanic activities, uplifts, invasion by seas, and erosion by wind or water (Sellards, Adkins and Plummer, 1978). These events guided the shaping of Texas landforms through geologic time and the subsequent development of parent materials to form the present array of soils found across the state.

A band of consolidated rocks lies across the center of Texas from the Rio Grande to the Red River. The parent materials derived from these rocks consist of sandstones and shales to the north and limestone to the south. A small inclusion of crystalline rocks marks the location of the granite basin (Jenny, 1941).

Flanking this band of consolidated rocks east and west are areas of unconsolidated rocks of variegated origin. The area to the east contains parent materials consisting of marl and chalk or sand, clays, and limestone. The area to the west contains parent materials consisting of desert alluvial fans, sands, and Great Plains materials (Jenny, 1941). These parent materials give rise to soils of varied characteristics, ranging in texture from sands to clays. The native vegetation reflects these soil variations.

Soils are created through the actions of climate, topographic relief, and the biotic community on a particular parent material over a period of time. Any significant change in one of the five formative factors results in a new or different soil. As discussed in Chapter 1, Appendix A, the climate, topography, and geology of the state are all extremely diverse. Chapter 7 of Appendix A, also presents a diverse picture of Texas' native plant communities.

In the roadside environment, the characteristics of relatively undisturbed, native soils are generally found in roadside management Zone 2. Familiarity with native soils that in many cases continue to exist within Zone 2 is important, particularly in determining how roadside vegetation management techniques would affect the environment in the different provinces. Where soils have been altered to meet highway designed specifications or to meet roadside drainage specifications (Zones 1a and 1b), most of the preconstruction soil characteristics have been markedly changed. Soil materials foreign to the site have been placed in these zones and compacted to meet construction requirements. This condition creates a non-natural and often extremely harsh soil environment in which vegetation must establish and grow.

1.1.1 Pineywoods

The Pineywoods area is a gently to strongly sloping dissected coastal plain. Elevation ranges from 61-213 m (200-700 ft), increasing from south to north.

The Pineywoods region is underlain by weakly-cemented sandstones, shales, mudstones, and lignites of the Cenozoic era, which are composed of varying proportions sand, silt, and mud. Delta loading ultimately caused some areas of the coast to subside and form fault zones and ridges of interbedded sand and shale running roughly parallel to the coast. The region is cross-cut by major streams which generally run from the northwest to the southeast. Ground water recharge occurs on sandy uplands.

Ultisols and alfisols dominate the Pineywoods region. See Table A2-1 and Figure A2-1.

1.1.2 Gulf Prairies and Marshes

The Gulf Marshes are low-lying coastal areas frequently covered with saline water, and vary from sea level to a few feet in elevation. The Gulf Prairies are nearly level, largely undissected plains extending from sea level to an elevation of 76 m (250 ft). Surface drainage is slow.

This ecological region occupies a portion of the Gulf Coastal Plains geological region, which is composed of weakly-cemented sandstones, shales, mudstones, and lignites of the Cenozoic era. These deposits document extensive seaward building by broad river deltas and related deposition structures and underlie the outer 80 km (50 m) or more of the Gulf Coast Plain. This delta loading ultimately caused some areas of the coast to subside and form fault zones and ridges of interbedded sand and shale running roughly parallel to the coast. Ground water recharge occurs on sandy uplands. The region is cross-cut by major streams which generally run from the northwest to the southeast.

Vertisols and entisols are the dominant soil orders in the Gulf Prairies and Marshes. See Table A2-1 and Figure A2-1.

1.1.3 Post Oak Savannah

The Post Oak Savannah is characterized by gently rolling and moderately dissected wooded plains. Elevation ranges from 91-244 m (300-800 ft).

This region lies on a portion of the Gulf Coastal Plains geological region, which is composed of weakly-cemented sandstones, shales, mudstones, and lignites of the Cenozoic era. Delta loading ultimately caused some areas of the coast to subside and form fault zones and ridges of interbedded sand and shale running roughly parallel to the coast. Ground water recharge occurs on sandy uplands. The region is cross-cut by major streams which generally run from the northwest to the southeast.

Alfisols and vertisols are the dominant soil orders. Ultisols occur to a lesser extent in the region. See Table A2-1 and Figure A2-1.

1.1.4 Blackland Prairies

The Blackland Prairie is characterized as a rolling and well-dissected prairie. Elevation ranges from 7-213 m (250-700 ft).

This region lies on a portion of the Gulf Coastal Plains geological region, which is composed of weakly-cemented sandstones, shales, mudstones, and lignites of the Cenozoic era. Delta loading ultimately caused some areas of the coast to subside and form fault zones and ridges of interbedded sand and shale running roughly parallel to the coast. Ground water recharge occurs on sandy uplands. The region is cross-cut by major streams which generally run from the northwest to the southeast. The Cretaceous "Austin Chalk" crops out in the northern and western portions of the Blackland Prairie.

Vertisols, alfisols, and mollisols dominate the region. See Table A2-1 and Figure A2-1.

1.1.5 Cross Timbers and Prairies

The Cross Timbers and Prairies region is characterized by its gently rolling landform. Elevation ranges from 152-457 m (500-1,500 ft) above sea level.

The Balcones and Whiterock Escarpments, which form the eastern boundary of the Cross Timbers and Prairies region, also delineate the boundary between weak, recent rock and older, competent rock in the state. The area is underlain by Cretaceous limestone, sandstone, and shale, which are unconformably overlain by upper Paleozoic sediments. This region, often called the Fort Worth Basin, contains thinner soils than the Gulf Coast Basin. Groundwater recharge occurs through fractured parent material. Significant faults mark the area.

Primary soils in the area are the mollisols and alfisols. See Table A2-1 and Figure A2-1.

1.1.6 South Texas Plains

The South Texas Plains are a nearly level to rolling landform. The area is slightly to moderately dissected by intermittent drainage ways. Elevation ranges from sea level to 305 m (1,000 ft).

This region lies on the Gulf Coastal Plains geological region, which is composed of weakly-cemented sandstones, shales, mudstones, and lignites of the Cenozoic era. Delta loading ultimately caused some areas of the coast to subside and form fault zones and ridges of interbedded sand and shale running roughly parallel to the coast. Ground water recharge occurs on the sandy uplands. The region is cross-cut by major streams which generally run from the northwest to the southeast.

Vertisols and alfisols dominate this region. Mollisols, inceptisols, and entisols occur to a lesser extent. See Table A2-1 and Figure A2-1.

1.1.7 Edwards Plateau

The Edwards Plateau is characterized as a deeply dissected, stony plain with broad and flat to undulating and hilly divides. Hilltops frequently are flat, surrounded by stair-stepped slopes. Elevation ranges from 366-914 m (1,200-3,000 ft) above sea level.

This region, bounded on the east and south by the Balcones Escarpment, is comprised of Cretaceous limestone, sandstone, and shale of the Mesozoic era, which are unconformably overlain by upper Paleozoic sediments. Groundwater recharge occurs through fractured parent material. Llano Uplift, one of the oldest geologic features in the state, is comprised of Pre-Cambrian igneous rock overlain by lower Paleozoic sediments.

The dominant soils are entisols, mollisols, and alfisols. See Table A2-1 and Figure A2-1.

1.1.8 Rolling Plains

The Rolling Plains area is characterized by a well-dissected, nearly level to rolling plain. Elevation ranges from 305-914 m (1,000-3,000 ft), however, a few of the larger valleys fall substantially below the level of the plain.

This region is underlain by Paleozoic rocks of continental and shallow marine limestone, sandstone, and shale. The headward migration of major streams has eroded more recent rock to reveal the surface. Groundwater recharge occurs through fractured parent material.

The soil of the Rolling Plains area is primarily composed of mollisols, and, to a lesser extent, alfisols and inceptisols. See Table A2-1 and Figure A2-1.

1.1.9 High Plains

The High Plains area is a relatively level plateau which contains two canyons of note, Tule and Palo Duro, along the Caprock Escarpment. There exist many shallow depressions, or playa lakes, which are intermittent in nature and may contain several feet of water and cover as many as 16 ha (40 ac) after heavy rains (TPWD, 1982). The elevation ranges from 914-1372 m (3,000-4,500 ft).

In the High Plains region, streams originating in the southern Rocky Mountains brought floods of gravel and sand into Texas and formed alluvial fans. These fans were deposited on older Paleozoic and Mesozoic rocks. After the streams lost their source in the Rocky Mountains, the eastern edge of this alluvial sheet began to retreat westward due to headward migration of streams to the south. This formed the caprock of the region. Groundwater recharge occurs through fractured parent material.

Alfisols and mollisols dominate the region. See Table A2-1 and Figure A2-1.

1.1.10 Trans-Pecos

The Trans-Pecos region is characterized by mountain ranges, rough, rocky land, and flat basins and plateaus. Elevation ranges from 762-2667 m (2,500-8,751 ft), and includes Guadalupe Peak, the highest point in Texas. The region includes the Guadalupe Mountains, Chisos Mountains, and Davis Mountains, in addition to others. Notable canyons occur along the Big Bend of the Rio Grande River and in the Guadalupe Mountains.

The Trans-Pecos region contains some of the oldest and most complex geology in Texas. Its mountains of uplifted Paleozoic and Cenozoic blocks form the southeastern tail of the Rocky Mountains. The mountains contain numerous igneous intrusions. Groundwater recharge occurs through fractured parent material. Streams are intermittent.

The dominant soils of the region are aridisols, entisols, and mollisols. See Table A2-1 and Figure A2-1.

1.2 Soil Erosion

One of the primary objectives in vegetation management along transportation corridors is to manage accelerated soil erosion. Erosion is defined as the process of detachment and transportation of soil materials by water, gravity, or wind.

The physical characteristics of soils within transportation corridors could be altered from their natural conditions by any disturbance during reconstruction or maintenance. Compaction of the soil surface limits permeability with a resulting increase in runoff. Steeper cut and fill slopes than those occurring naturally accelerate flow velocity and increase erosion potential.

A potential for erosion exists in all unpaved roadside management zones. Regrading in Zone 1b to correct pavement drop-offs leaves the graded area temporarily bare, but bermudagrass or other vegetation arising from residual plant parts could soon cover the area. Bare patches or those with weak cover in Zone 2 may reflect inhospitable subsurface materials. In eastern Texas, pyritic materials uncovered during construction weather to an extremely acid condition which keeps the slope bare of vegetation and susceptible to erosion. Fill areas constructed from these materials would be difficult to vegetate.

Soil erosion requires three conditions: a source of water or wind energy, detachable soil particles, and transport of the detached particles. Erosion may result from sheet (surface) flow or from concentrated (channel) flow. Sheet flow occurs when the rate of precipitation exceeds the rate of soil infiltration, and the flow velocity is dependent on the length and gradient of the slope.

Mass erosion, the downslope movement of large amounts of earth materials, occurs when the force of gravity overcomes the forces of internal cohesion and frictional resistance of soils, unconsolidated geologic materials, or bedrock. Mass movement events are categorized into five types (creep, flow, slide, falls, and complexes) depending on speed, water content, and materials. Creep is the slow movement of soil and rock debris down a vegetated slope. Flows are movements within displaced earth mass such that their velocities resemble those of a viscous fluid. Slides are rapid movements caused by finite shear failure along one or more surfaces. Falls are movement of earth materials such that the mass travels most of the distance through the air by free fall or rolling and bounding. Complexes are combinations of two or more of the other mass movements.

Mass erosion in Texas is confined to slides on some long slopes and to microslides or "blowouts" on constructed ramps and approaches to structures, or on shallow cut slopes.

A vegetative cover is preferred for controlling surface erosion on slopes flatter than 25 percent. Vegetation is more difficult to establish and may present a thinner cover on slopes steeper than 25 percent. Concentrated flows often are difficult to manage with vegetation alone, and require mechanical aids such as channel liner materials or gabions. The Universal Soil Loss Equation (USLE) and some modifications have been useful in predicting surface erosion.

A Modified Universal Soil Loss Equation (MUSLE) has been proposed by TxDOT as a guide to predict soil loss from erosion and to determine the effectiveness of various strategies to control erosion (TxDOT 1993).

Mass movement due to the forces of gravity and water vary widely, even within vegetation regions, because of the wide variation in soil characteristics, geology, topography, and climate.

It is essential for stable vegetative cover to be maintained on highway ROWs traversing all vegetation regions. Frequent use of soil-intensive mechanical equipment such as graders, discs, and front-end loaders would likely cause mass soil movement. Compaction by mechanical equipment could contribute to increased runoff and erosion.

2.0 Environmental Consequences of Treatments

2.1 Chemical Techniques

Spot and selective chemical treatments for vegetation management generally do not affect the geology or soils along Texas highway corridors. Even with small-scale use of herbicides, applications must be target specific so that no off-site effects occur. While improper application of selective herbicides may indirectly affect soil microorganisms, their controlled use in terms of quantity and timing should ensure no negative impacts on soils and geology.

Spot applications of chemicals to individual ant mounds would not be expected to adversely impact geology and soils.

2.2 Cultural Techniques

Cultural techniques have no adverse impacts on geology and soils. While the use of machinery for seeding may cause compaction and minor increased erosion, cultural techniques stabilize surface soils and reduce both the potential for and the impacts of surface erosion and slope failures over the long term by establishing stable vegetative cover.

2.3 Biological Techniques

Although plant pathogens could alter soil microorganism populations, the effects most likely would be below detectable levels. Thus, biological control of undesirable vegetation would have no negative impacts on soils and geology within Texas.

2.4 Mechanical Techniques

Mechanical techniques have greatest potential to impact soils by causing compaction and exposing the soil to surface erosion. Wet soils could be severely compacted by heavy equipment used for mechanical treatment. Properly controlled mowing and manual treatment methods generally have a low potential to cause soil erosion because they retain substantial soil cover. Improper mowing leaves the soil susceptible to erosion. Grading, however, creates a high potential for erosion because exposed soil surfaces could easily be eroded by water or wind.

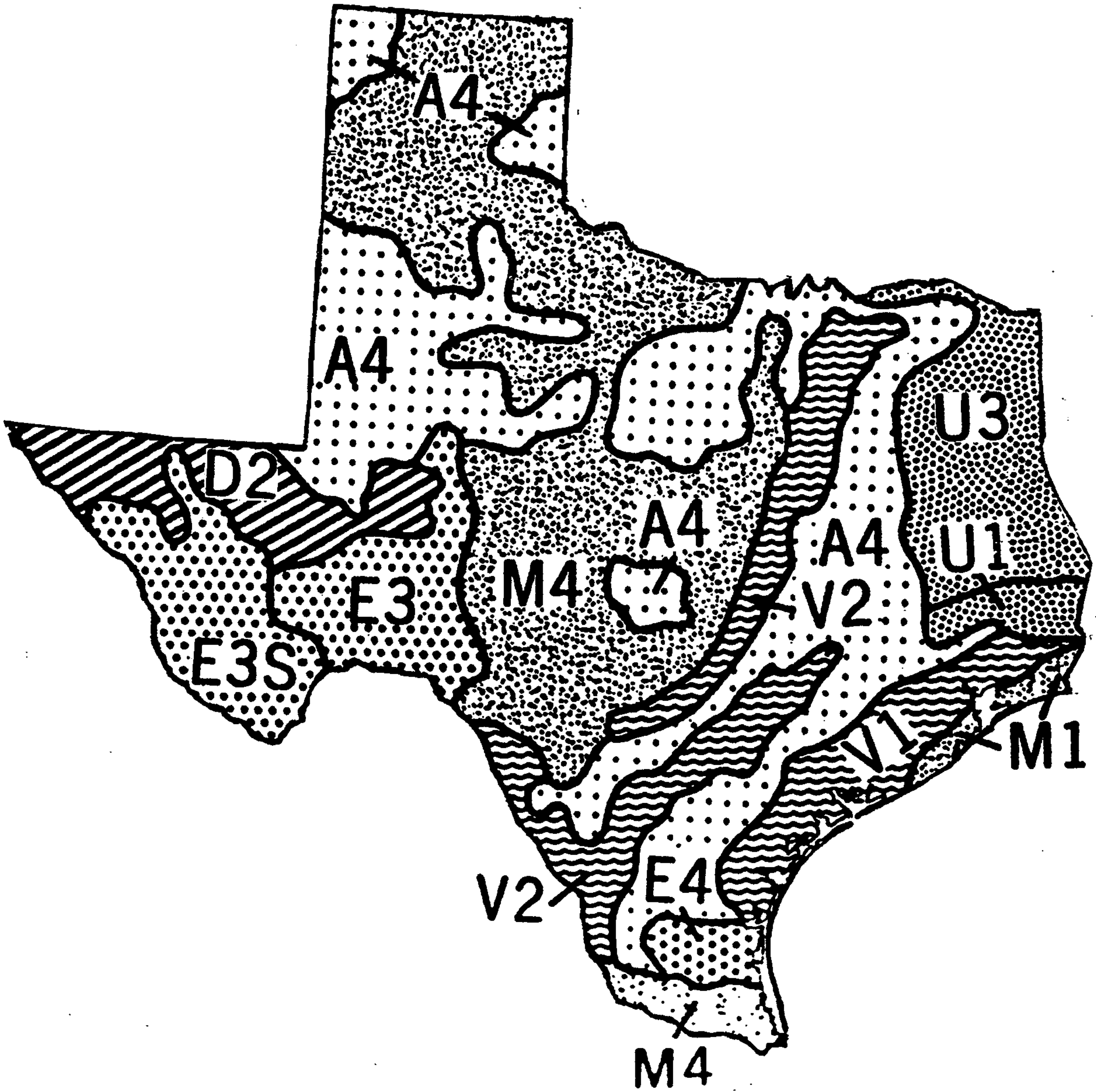
Soil compaction resulting from equipment used for mechanical vegetation control is of most concern with moist, fine-textured soils and dry sandy soils.

Frequent, close mowing or chemical destruction of deep-rooted vegetation has the potential to reduce slope stability. If manual control is used very intensively, it could impact slope stability in the same manner.

2.5 Unavoidable Adverse Impacts

The maintenance of a dense vegetation cover in Zones 1b and 2 minimizes surface erosion. Frequent use of mechanical equipment on roadsides in programmed maintenance may induce impacts on soil favoring erosion. Mass soil movement is most common in clay soils having high swell-shrink tendencies. Soil cracks provide deep channels for water accumulation and favor the development of slippage zones.

Figure A2-1. Locations of Dominant Soil Orders in Texas



A4 - Alfisols M1, M4 - Mollisols
D2 - Aridisols U1, U3 - Ultisols
E3, E3S - Entisols V1, V2 - Vertisols

Source: Brady, 1974.

Table A2-1. Descriptions of Dominant Soil Orders in Texas

Order	Defining Characteristic	Description	Vegetation Region Occurrence
Alfisols	High aluminum and iron content	Well-developed B horizon from leaching of clays in the A horizon; moderate age has not resulted in leaching of nutrients; relatively high base content (Mg++, Ca++, NH++++, Na+), although surface horizon may be strongly acidic; little buildup and shallow penetration of organic matter (less than 1% in A horizon)	Extensive in Texas Regions 1, 3-9
Aridisols	Found in arid environments	Low plant-available water for extended periods; low in organic matter; high salt content (calcium carbonate or sulfate common) but often fertile; high base content; may have clay horizons	Region 10
Entisols	Recent alluvial deposits	Soil profiles usually not developed; low in organic matter; texture and chemical properties vary considerably	Regions 2, 6, 7, and 10
Mollisols	Soft, organic	Deep, dark fertile A horizons; high in organic matter; rich in bases; formed under grasslands (semi-humid conditions)	Regions 5-10
Ultisols	Ultimate profile development	Older soils with very strong profile development; intensely leached, resulting in substantial clay translocation from A to B horizon; low base content	Regions 1 and 3
Vertisols	High clay content	Soils with high content of swelling clays and wide, deep cracks in some seasons	Regions 2, 3, 4, and 6

Source: Brady, 1974.

Appendix A - Chapter 3

1.0 Air Quality

This section discusses existing conditions that influence background air quality in Texas. The discussion provides information on natural conditions (e.g., topography, climate), sources of anthropogenic emissions (e.g., vehicle, industrial, and home heating/cooling), and other factors as a basis for determing potential impacts from the four alternative pest management treatments (chemical, cultural, biological, mechanical) addressed in this EIS.

During periods of locally stable air, most contaminants would be concentrated in a relatively small area near the point source of emission. Contaminants may travel great distances on moderate to strong winds, but they would be rapidly dispersed and diluted to low concentrations. During summer, hydrocarbons and nitrogen oxides react in sunlight to cause smog, odor, and reduced visibility. Houston/Galveston, Beaumont/Port Arthur, Dallas/Fort Worth, and El Paso are classed as nonattainment areas with specific actions required under the Clean Air Act Amendment of 1990.

Wind velocities in western and northwestern Texas during spring often create severe dust storms that dramatically increase the load of total suspended particulates. Elevated levels of particulates carried by high winds may lead to increased eye and respiratory irritation. Small suspended particulates (e.g., particles less than 10 micrometers in diameter, referred to as PM-10) when inhaled may be deposited deep in the lung and lead to increased potential for respiratory disease.

The principal sources of contaminants affecting air quality within Texas could be emissions from motor vehicle exhausts, industrial processes, use of industrial fuels, and disposal of refuse debris. Dust and smoke from agricultural and forestry practices and wildfires could reduce air quality on a localized, short-term basis.

Contaminants generated by these processes primarily include sulfur oxides (SO_X), particulates, carbon monoxide, nitrogen oxides (NO_X), fluorides, and hydrocarbons. Except for exhaust from motorized equipment (which may contain carbon monoxide, sulfur oxides, nitrogen oxides, hydrocarbons, and particulates), none of these contaminants would be generated by pest management activities in transportation corridors. Only dust arising from mechanical treatment methods may significantly impact local air quality.

1.1 Odor

Some of the emissions sources listed above may produce adverse odors. Various sources of combustion (vehicle and motorized equipment exhaust emissions, industrial fuel use) emit objectionable sulfur oxides, nitrogen oxides and hydrocarbons, as well as the colorless and odorless carbon monoxide, carbon dioxide, and water vapor. These emissions may have adverse impacts on the existing air quality along transportation corridors prior to any additional impacts attributable to pest management practices.

Existing sources of odors associated with highway transportation corridors are generally dominated by vehicle exhaust emissions. Other minor sources of highway - related odors include tar and asphalt from road construction and maintenance, volatilization of existing materials during hot weather, and occasional road kills.

Odors from roadside pest management may originate from treated vegetation from some chemicals treatment (herbicides and insecticides). Vegetation odors such as freshly mowed turf may have many subtle variations, depending upon species composition, and could generally be considered pleasant in character. Natural decomposition processes associated with decaying vegetation and marshy areas also may yield objectionable odors.

Some herbicides and insecticides possess a characteristic odor (Table 3A-1) which may persist as spray vapor for a short time following treatment. Persistence of any odor following application depends on the material applied, weather conditions at the time of treatment (temperature, wind speed and direction), and application techniques. Strategies to reduce odor include spraying using a low nozzle pressure to reduce the number of fine particles, incorporating a spray thickener to increase droplet size, scheduling applications so that any wind carries spray particles away from traffic if possible, and applying specified amounts of spray to designated target areas.

It is important to note that the presence of an odor does not necessarily indicate that a chemical application has been improperly administered, or that there is a risk to human health or the environment. In many cases (depending on the properties of the specific chemical) the odor threshold may be at a concentration substantially lower than the regulatory levels of concern for potential adverse health effects.

TxDOT applies herbicides and insecticides in selective, spot treatments to small areas. Applied properly, these treatments emit little or no odor. Further, chemicals used by TxDOT generally have a low risk (see Appendix B, Chapter 2).

1.2 Chemical Content

Various emissions from sources other than pest management practices contribute to chemical contamination of the air. Combustion sources in general, as well as vehicle exhaust in particular, contribute varying amounts of sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide, and carbon dioxide. Incompletely burned gasoline from poorly-maintained vehicles may contribute emissions of a variety of volatile organic compounds (VOCs), including benzene, a known human carcinogen. Industrial emissions of chemicals are highly dependent on the chemical processes, industrial processes, and types and effectiveness of air pollution control equipment used (e.g., scrubbers to remove sulfur dioxide from stack gases).

1.3 Particulate Content

Many of the existing sources of emissions result in increased levels of airborne particulates. Motor vehicle and other motorized equipment exhaust, particularly diesel-fueled engines, yield relatively high levels. Particulate emissions from industrial activities vary widely, depending largely on the specific industrial processes, combustion temperatures, and air pollution control equipment used (e.g., electrostatic precipitators and baghouses to remove fine particulates).

Smoke from roadside burning of vegetation (brush fires) and home heating with wood (especially poorly-maintained fireplaces and wood stoves) may contribute to poor air quality in part because of emissions of hydrocarbon-bearing particulates. Dust and smoke from agricultural and forestry practices may also contribute to elevated levels of suspended particulates. As described above, in the western and northwestern portions of Texas, high seasonal winds often result in severe dust storms that dramatically affect air quality.

2.0 Environmental Consequences of Treatment Methods

This section summarizes the potential environmental consequences of the four pest management treatment methods with respect to air quality. Where appropriate, a brief discussion of potential mitigation options is provided.

2.1. Chemical Techniques

Potential environmental consequences of chemical treatment methods on air quality include:

- Potential occupational exposure of chemical applicators from inhalation of spray or direct contact with chemicals (see also Appendix B, Chapter 2).

- Potential exposure of other human populations, e.g., downwind residents during conditions conducive to spray drift, passing motorists, or children playing in treated areas (see also Appendix B, Chapter 2).

- Potential exposure of non-target plant species, wildlife, or other organisms entering or visiting the application area during periods when vapors of an applied chemical are present.

- Potential odor impacts associated with use of specific chemical formulations (Table A3-1).

Potential mitigation methods include:

- Implementation of appropriate occupational health and safety training and controls for herbicide applicators (e.g., training, licensing, use of protective clothing, use of respiratory protection).

- Restriction of herbicide and insecticide application to environmental conditions that reduce the probability of drift (e.g., follow federal, state, local, and label directions regarding approved application practices; restrict application during weather conditions conducive to drift).

- Selection and application of herbicides in a manner consistent with federally-approved label warnings to minimize the potential for exposure to non-target species (e.g., plants, wildlife, aquatic organisms).

- Selection and application of herbicides and insecticides that have the lowest degree of adverse odor impacts associated with an acceptable degree of herbicidal and insecticidal effectiveness (see Table A3-1).

2.2 Cultural Techniques

Potential environmental consequences associated with cultural treatment techniques include the following:

- Preparation of seedbed or planting areas could result in particulate emissions (e.g., airborne dust from soils disturbed by machinery; dust emissions from the effects of wind erosion on bare soil). These impacts would be expected to be short-term and localized. Conversely, after implementation of cultural techniques to promote healthy desirable plant communities, the potential for soil erosion would be expected to decrease with the development of root systems and groundcover.

Positive impacts of enhanced vegetation:

- Consumption of carbon dioxide and production of oxygen (O_2) by plants during photosynthesis (e.g., reducing local contributions to the "greenhouse effect" from CO_2 and replenishing air with fresh O_2).

- Reduction of acreage requiring annual maintenance could result in reduction of vehicle emissions associated with alternative vegetation management activities (e.g., emissions from truck-mounted spray equipment for herbicide application and mowers).

Potential mitigation methods that could be used to reduce the impacts of cultural techniques on air quality include:

- Restriction of activities such as the disturbance of soils to periods when weather conditions are likely to result in minimal generation of particulate emissions, e.g., when soils are damp.

- Use of dust suppression techniques where appropriate, e.g., water spray to reduce airborne dust emissions from soils disturbed by machinery, and mulch to cover small areas of exposed soils to prevent wind or water erosion.

- Seeding or planting and mulching as soon as practical after soil preparation is completed.

2.3 Biological Techniques

Biological control agents are considered to have no adverse impacts on air quality when properly applied.

2.4 Mechanical Techniques

Potential environmental consequences of mechanical treatment techniques on air quality include:

- Odor impacts from exhaust emissions, e.g., from gasoline or diesel powered machinery.

- Other adverse air quality impacts associated with exhaust emissions from machinery (VOCs, carbon monoxide, particulates, NO_X, SO_X, etc.).

- Potential generation of airborne particulates during activities such as grading and mowing.

Potential mitigation methods that could be used to reduce the impacts of mechanical techniques on air quality include:

- Where feasible, use electrically-powered equipment as a replacement for gasoline or diesel equipment to reduce objectionable odors and potential adverse health effects from exhaust emissions. Alternative fuels such as compressed natural gas (CNG) also mitigate many of the objections to petroleum fuels.

- Restrict activities such as the disturbance of soils during mowing and cultivation to periods when weather conditions are likely to result in minimal generation of particulate emissions (when soils are damp).

2.5 Unavoidable Adverse Impacts

Potentially unavoidable impacts of roadside vegetation management on air quality may include the following:

- Odor during application of herbicides or insecticides.

- Dust emissions from activities that disturb soils which must be conducted during dry weather, for example, cultural or mechanical techniques.

- Exhaust emissions from activities that require the use of motor vehicles or gasoline/diesel powered equipment.

- Risk of exposure of people, wildlife, and other organisms to airborne chemicals in areas where it would be impractical to remove potentially exposed organisms or prevent their entry during or shortly after chemical applications (see also Appendix B, Chapter 2).

Table A3-1. Odor and Appearance of Chemicals Used by TxDOT

Product	Appearance	Odor
Herbicides		
Arsenal®	Clear, blue liquid	Slight Ammonium odor
Escort®	Off-white soild	Odorless
Garlon 4®	Amber liquid	Not Available
Oust®	Off-white solid	Odorless
Pathfinder®	Yellow to amber liquid	Minimal
Roundup®	Clear, viscous amber-colored solution	Odorless
Rodeo®	Colorless solution	Odorless
Transline®	Dark brown clear liquid	Sweet
Velpar L®	Light yellow liquid	Alcoholic
Insecticides		
Diazinon®	Amber liquid	Slight sulfur-like
Dursban®	Yellow liquid	Solvent-type odor
Logic®	Yellow granular soild	Not Available

Source: WSDOT Roadside Vegetation Management EIS and chemical Material Safety Data Sheets

Appendix A - Chapter 4

Draft EIS

Pest Management Program

1.0 Quality

1.1 Surface Water

Protecting water quality is one of the primary reasons for maintaining a healthy vegetative cover in the roadside environment. An understanding of the process in which vegetation affects water movement is important in defining how vegetation management techniques affect water quality.

1.1.1 Fresh Waters - Fresh water is defined as all non-salt water lakes and drainage waters including lakes, ponds, rivers, creeks, and irrigation canals. The potential water quality impacts from roadside vegetation management would be particularly important where highways lie in close proximity to these waterways.

The quality of water in streams draining undisturbed lands typically is high in Texas. However, where the soil surface of highway ROWs has been altered from its natural condition or modified by designed drainage facilities (Zones 1a and 1b), surface water quality may be adversely affected. In addition to eroded soil, highway runoff may carry residue from the wear of the road surface and various automotive and other chemical contaminants that were spilled or intentionally placed on the pavement or roadside. The most effective method to protect surface water quality from these roadside pollutants is to maintain an adequate vegetation cover and a permeable soil surface that filters the contaminants from runoff. High volume stormwater runoff, retention, or detention areas are often built to temporarily impound runoff waters and remove contaminants.

The principal influence on surface water movement is the hydrologic regime which includes the combined effects of climate, soils, geology, topography, and vegetation. Because of the great topographic variation found in Texas, many different hydrologic regimes prevail, roughly coinciding with vegetation regions. Annual precipitation ranges from 1422 mm (56 in) in eastern Texas to 203 mm (8 in) in western Texas.

Movement of water across the soil surface until it reaches a defined natural stream channel is known as runoff. Since the soil surface on highway ROWs is usually disturbed during construction and maintenance, the infiltration capacity may be significantly reduced and runoff may occur. Moreover, the impervious road surface creates additional runoff.

Water quality may be adversely affected when increased runoff causes erosion of soils and sedimentation in receiving waters. Sediments create turbid conditions that restrict light in the stream environment and interfere with the respiration of fish. Accumulation of fine sediment on the stream bottom may also interfere with fish spawning and reduce the survival of eggs and emergence of fry. In addition to the physical effects of sedimentation, harmful chemicals and excess nutrients which readily attach to sediment particles may be carried into waterways from highway ROWs. Thick vegetative cover and carefully designed drainage structures may be necessary to reduce runoff, control erosion, and protect water quality in and downstream from these ROW areas.

1.1.2 Marine Waters

The marine waters of Texas include the coastal waters of the Gulf of Mexico. Since much of the coastal area is an estuary, its natural properties are affected by the inflow of freshwater, particulerly surface water from rivers and streams. As in freshwater environments, water quality of marine waters also can be adversely affected by chemicals transported by runoff and runoff-induced erosion.

1.2 Groundwater

The term groundwater is used here to broadly mean all water below the ground surface. Protection of groundwater quality is of concern in roadside pest management because of its importance as a resource for the public drinking water supplies, irrigation, and industrial uses. The roadside environment may contain a variety of contaminants that potentially can degrade the quality of susceptible underlying aquifers and subsequently impact their viability as a resource. Every effort must be made to keep potential roadside contaminants from reaching underlying aquifers.

Groundwater occurs in two different zones. One zone, the unsaturated zone, occurs immediately below the land surface in most areas and contains both water and air. The unsaturated zone is almost invariably underlain by a saturated zone in which all interconnected openings may be full of water. Water in the saturated zone is the only groundwater that is available to supply wells and springs for use as a water resource.

Inflow to the groundwater system is through precipitation, whereas outflow takes place as streamflow. Precipitation initially wets vegetation and other surfaces and begins to infiltrate the ground. Infiltration rates vary widely depending on land use, permeability of surface and near-surface soils, underlying geologic materials, land slope, vegetative cover, and amount of precipitation. Vegetation is important in that it affects the soil storage component of the water balance that can effectively reduce the amount of water available for the recharge of underlying aquifers. Infiltration rates vary from high in mature forests and sandy soils to low in clayey and silty soils to zero in paved areas. If the rate of precipitation exceeds the rate of infiltration, overland or surface runoff occurs.

The first infiltration replaces soil moisture which subsequently percolates slowly across the unsaturated zone to the zone of saturation. Water in the zone of saturation moves downward and laterally to sites of groundwater discharge such as springs on hillsides, or seeps in the bottoms of streams and lakes, or beneath the gulf.

Aquifers occur within the saturated zone. Aquifers are defined as permeable geologic units (including rock and consolidated and unconsolidated sediments) that transmit and yield significant water in a usable quantity to a well or spring. Common aquifers include unconsolidated sands and gravels, permeable sedimentary rocks such as limestones and sandstones, and heavily fractured volcanic and crystalline rocks.

Significant groundwater movement is generally in a lateral direction through aquifers. Groundwater movement through aquitards is relatively slow and restricted compared to aquifers. Aquitards are geologic units of low permeability that restrict the movement of groundwater either into or out of adjacent aquifers. Common aquitards include clays, shales, and dense crystalline rocks.

Another type of groundwater movement is related to surface water runoff and is known as subsurface stormflow. Subsurface stormflow is generally only significant when it occurs within highly permeable soils on hillslopes that feed deeply-incised channels. It generally occurs within the soil profile and only during high precipitation rates. When subsurface stormflow discharges to streams or channels, it can be a significant factor affecting slope stability.

The quality of groundwater underlying roadways can be affected by the use of some herbicides and insecticides. The mineral composition and physical characteristics of soils and rocks may affect pollutants in several ways. Organic substances and other biodegradable materials tend to be broken down both by oxidation and by bacterial action in the unsaturated zone.

The hydraulic and chemical characteristics of the soils and rocks interact with the physical and chemical properties of pesticides to determine the path of pollutants and their rate of movement. Substances dissolved in water move through the most permeable zones with the water, except when they have been tied up or delayed by adsorption. Certain earth materials, especially clays and organic matter, may adsorb trace metals and certain complex organic pollutants as they move through the underground environment.

Use of herbicides and insecticides along roadways potentially may introduce organic chemicals to the underlying groundwater system. However, several mechanisms tend to prevent or retard the migration of most organic substances from the land surface or soil horizon into deeper groundwater aquifers. These mechanisms include the small areas treated, and chemical precipitation, chemical degradation, volatilization, biological degradation, biological uptake, and adsorption of applied materials. Furthermore, many organic substances have extremely low solubility in water. This generally limits appreciable migration of large quantities of herbicides and insecticides into groundwater.

Unfortunately, solubility constraints may not totally prevent migration at significant concentration levels. Some organic substances have appreciable solubility in groundwater and may have significant mobility, particularly in sands and gravels.

2.0 Stormwater

Stormwater is runoff water originating from precipitation which is transmitted downhill through sheet flow, rivulets, channels, drainage ditches, pipes, creeks, streams, and rivers.

Precipitation does not create stormwater in all situations. Stormwater generally is not produced on undisturbed forest lands in Texas for example. Permeable soils and dense multilayered vegetation in east Texas forests combine to absorb and infiltrate most precipitation without surface runoff. When natural conditions are altered, increases in the amount and intensity of runoff may result.

Major factors influencing amount and rates of stormwater runoff from transportation corridors include:

- Amount and intensity of precipitation;
- Permeability or infiltration capacity of soil;
- Distribution and amount of impervious surface;
- Soil moisture storage capacity;
- Steepness of terrain;
- Type of vegetation or other soil surface cover; and
- Distance and length of slope to a receiving water channel or body.

Highway corridors produce stormwater because some of these factors have been changed from the original undeveloped conditions. Road surfaces generally prevent infiltration of precipitation, resulting in large amounts of stormwater runoff. Soils on slopes are often compacted to maintain stability, which removes much of their natural infiltration capacity. Additionally, cut and fill slopes often are so steep that even small amounts of rain will be converted to runoff.

3.0 Environmental Consequences of Treatment

3.1 Waterways and Hydrologic Systems

Roadside pest management in Texas can affect the hydrology of drainage basins and nearby waterways. An understanding of the hydrologic process and how it is affected by vegetation management techniques is important in determining potential impacts. Hydrologic processes affected by roadside vegetation management include surface water infiltration into the soil column and runoff into streams, lakes, estuaries, and wetlands. The potential impact of vegetation control measures on infiltration and runoff vary with the treatment method used and situation-specific local environment.

Vegetation management affects the hydrologic process by influencing the rate of infiltration and percolation to groundwater as well as the amount of runoff and evapotranspiration. Since roadside management Zones 1a and 1b have been highly disturbed and, in the case of Zone 1a, paved, infiltration rates may have been significantly reduced resulting in increased surface flow.

Another factor that affects roadside infiltration of precipitation and pavement runoff is the highway design. Highways may be constructed and maintained to keep the subgrade and shoulders dry by minimizing infiltration. Paved shoulders (Zone 1a) and compacted soils (Zone 1b) prevent infiltration into the materials supporting the roadway.

Highways are considered linear features on the landscape, and they generally comprise only small areas of the total drainage basin for lakes and streams. Thus, the impact of the highway corridor on the quantity and quality of waters yielded by the affected watershed should be minimal in most cases. However, roadside vegetation management practices could have significant effects on nearby lakes or ponds, local groundwater features, or small streams flowing parallel to the highway. Changes in water quality of runoff and changes in surface groundwater levels that affect slope stability are of greatest concern in the highway corridor.

The potential environmental impacts to waterways and hydrologic systems from the roadside pest treatments used by TxDOT are discussed in the following sections.

3.1.1 Chemical Techniques

Vegetation management performed through chemical treatments potentially can have a range of impacts on waterways through changes in the hydrologic regime. Changes in vegetative cover, rather than the chemicals themselves, have potential to affect hydrology. The application of highly selective herbicides to remove target species that are minor components of a well-established stand of roadside vegetation should not be expected to effect measurable change in the hydrologic characteristics of the site. TxDOT applies chemicals in narrow bands or as spot treatments, minimizing the impacts on the hydrology of roadsides. These conservative treatments target only a tiny fraction of the land in any one watershed. Further, chemicals applied by TxDOT are rapidly degraded by contact with sunlight, water, or soil. See Appendix B, Chapters 1 and 4 for data regarding fate and mobility in water and soils.

Chemical application to individual ant mounds is not expected to adversely impact water resources.

3.1.2 Cultural Techniques

Cultural techniques used for vegetation management activities generally should not have an impact on waterways and hydrologic systems. Cultural techniques of establishing vigorous native plant communities should provide a positive benefit to waterways and hydrologic systems by developing more permeable surfaces to reduce stormwater runoff.

3.1.3 Biological Techniques

Biological vegetation control management activities should have no impact on roadside hydrologic systems. No significant change in the relationship among runoff, infiltration, and evapotranspiration should be expected from this control technique. Biological control techniques could only affect the hydrologic system in an unusual case of extensive plant mortality or a major shift in the plant species composition that influence evapotranspiration rates, and these changes would be expected to occur over a period of time.

3.1.4 Mechanical Techniques

Mechanical vegetation control using heavy machinery on vegetated ROW areas potentially could reduce infiltration by compacting the soil surface and reducing vegetative cover. These two shifts in the hydrologic regime would contribute to increased runoff. Use of machinery on wet soils and steep slopes should be avoided to reduce the impact on infiltration rates. Of all vegetation control techniques, mechanical has the greatest potential to affect hydrography in a local watershed. Manual vegetation controls would have minimal impacts on roadside hydrologic systems.

3.1.5 Unavoidable Adverse Impacts

In most cases, unavoidable adverse impacts to waterways and hydrologic systems resulting from roadside pest management should be minor. Grading and discing to eliminate undesirable vegetation should be discouraged to avoid adverse impacts to waterways. Driving heavy machinery on roadsides should also be kept to a minimum to avoid soil compaction or disturbance with subsequent increases in runoff.

3.2 Water Quality

Roadside vegetation management techniques have the potential to affect the quality of groundwater, surface runoff, and downstream receiving waters. Potential impacts to water quality from roadside vegetation management activities primarily are related to accelerated erosion and the loss of water treatment functions. Accelerated erosion impacts from vegetation management are closely associated with soil disturbance and compaction that influence the infiltration and runoff process described in the previous section on waterways and hydrologic processes. Runoff or infiltration of herbicide and insecticide residues from roadside management activities potentially could affect quality of groundwater and surface waters. See Appendix B, Chapter 4, for an assessment of surface runoff and leaching loss potentials for each of the 10 chemicals evaluated for TxDOT's pest management program.

Roadside vegetation provides an important function in water quality control by providing both a protective cover from raindrop impact energy that accelerates erosion, and a filter strip for intercepting pollutants in highway runoff. Without the protective vegetative cover, accelerated erosion results in increased sedimentation and turbidity in receiving waters. Asplund, et al., (1980) identified vehicular traffic, pavement deterioration, and atmospheric dustfall as the probable major contributing sources of highway pollutants that could lead to water quality degradation. Metals and hydrocarbons in runoff (primarily adsorbed on eroded sediment particles) may have toxic effects on aquatic life. Nutrients may also stimulate undesirable growth of algae and aquatic plants. Roadside vegetation provides an important water quality treatment function by filtering pollutants from runoff. Treatments that favor dense stands of vegetation will benefit water quality.

Within East Texas, roadside plant species provide continuous surface coverage. In West Texas, summer drought often reduces the effectiveness of plant cover to protect the soil surface. Vegetation management practices in these areas need to develop a dense cover of plant species that can withstand harsh environmental conditions.

The potential impacts on surface and groundwater quality by specific roadside pest management alternatives are addressed in the following sections.

3.2.1 Chemical Techniques

Both direct and indirect water quality impacts can result from chemical vegetation management. Direct impacts would result if: 1) water resources receive chemical spray, drift, or spills, or 2) herbicides were applied in large-scale applications directly to impervious surfaces, with runoff transporting chemicals to adjacent water resources. Indirect impacts could result if herbicides eliminated vegetative cover to the degree that erosion was increased and biofiltration functions were lost. In some areas dominated by undesirable plant species, chemical techniques should be combined with cultural techniques to simultaneously promote the establishment of desirable species and maintain a functional vegetation cover.

TxDOT works closely with Texas Natural Resource Conservation Commission (TNRCC) to minimize chemical impacts to water, particular in areas of direct aquifer recharge. This cooperation and consultation helps ensure adequate protection of water resources.

Unavoidable adverse impacts to water quality from selective herbicide applications as used by TxDOT in highway corridors should be minimal if regulations governing the use of herbicides are followed closely. Pesticides proposed for use by TxDOT are registered with the U.S. EPA and the Texas Department of Agriculture. They should be applied according to registered label directions by a licensed pesticide applicator. See Appendix B, Chapter 4 for more detailed discussion of each chemical evaluated for TxDOT's use.

3.2.2 Cultural Techniques

Similar to chemical techniques, cultural techniques for managing roadside vegetation may have direct and indirect adverse impacts on water quality. Application of a surface mulch over a seeded area will reduce water quality impacts from a bare seedbed. It may be necessary to avoid using nitrogen fertilizers in planting operations in areas where there is a potential to contaminate drinking water supplies.

3.2.3 Biological Techniques

Biological control methods do not disturb the soil, thus accelerated erosion and sedimentation impacts on water quality are minimal. Only where biological control results in extensive plant mortality would water quality be affected by reducing the function of vegetation in filtering pollutants from stormwater.

3.2.4 Mechanical Techniques

Mechanical vegetation management activities that remove extensive areas of vegetation reduce the effectiveness of these biofiltration areas for pollutant removal. Soil-intensive management should be used only as needed, and revegetation should be undertaken immediately thereafter. In addition, excessive mowing, cutting, and trimming may temporarily reduce the ability of vegetation to protect the soil surface and filter pollutants from stormwater.

Mechanical control techniques that use wheeled machinery are most likely to compact or disturb soils. This may result in significant water quality impacts from increased sedimentation resulting from aggravated sheet, rill, and gully erosion, particularly on steep slopes. Potential water quality impacts from mechanical control can be minimized by avoiding the use of wheeled machinery on sensitive areas and maintaining a dense cover of vegetation on steep slopes and in drainage swales.

3.2.5 Unavoidable Adverse Impacts

TxDOT's standard operating practices should avoid significant adverse impacts to water quality which could occur following roadside pest management. Water quality can be protected or even enhanced by establishing and maintaining vegetation as a biofiltration treatment system to remove pollutants from highway runoff. Effective roadside pest management for water quality protection should avoid improper application and spills of herbicides and insecticides, minimize soil disturbance and compaction, and encourage a protective vegetative cover that minimizes erosion.

Appendix A - Chapter 5

1.0 Increased High Water

Transportation routes historically have followed streams and rivers. Many miles of highways have been located in flood plains due to topographic constraints, and land development has grown up around these transportation corridors. Encroachment onto flood plains by highways and associated developments has been an integral part of economic growth in Texas.

Although the construction of highways has had a major impact on flood plains in Texas, pest management in the highway ROWs is not expected to have a major influence on high water levels. As discussed in Chapter 4 of Appendix A, increases in runoff from ROWs could occur within the corridor as a result of soil compaction or decreased evapotranspiration. However, the incremental increase in runoff would not normally have a measurable effect on high water levels because the ROWs represent only a small portion of the entire watershed contributing to floods. Vegetation management does not involve any construction that would displace flood waters and would not be expected to influence flood plain development.

2.0 Natural and Beneficial Flood Plain Values

Flood plains provide many natural and beneficial values, including fish and wildlife habitat, scenic beauty, opportunities for scientific study and outdoor recreation, agriculture, forest resources, natural moderation of floods, water quality maintenance, and groundwater recharge. The potential impacts to these values can be found in other chapters of this EIS.

3.0 Environmental Consequences of Treatment Methods

3.1 Chemical Techniques

Pest management using chemical techniques is not expected to impact flood plains, except for the minor potential impacts of increased runoff addressed in Chapter 4 of Appendix A. Increases in runoff and high water levels should be minor if soil compaction is minimized and selective herbicide treatments are used to maintain desirable vegetation.

3.2 Cultural Techniques

Vegetation management through cultural techniques is not expected to impact flood plains.

3.3 Biological Techniques

Vegetation management using biological techniques would not have any impacts on flood plains.

3.4 Mechanical Techniques

Mechanical vegetation management has the potential to impact flood plains through minor increases in runoff resulting from soil compaction or reduced evapotranspiration. Potential increases in runoff are addressed in Chapter 4 of Appendix A. Increases in runoff should be minor if soil compaction is minimized and plants are removed selectively.

3.5 Unavoidable Adverse Impacts

No unavoidable adverse impacts to flood plains would be anticipated from roadside pest management.

Appendix A - Chapter 6

Draft EIS
Pest Management Program

1.0 Description of Wetlands

Wetlands, in the form of marshes, swamps, or bogs, provide a transition between terrestrial and aquatic land and water environments.Current delineation utilizes 1987 EPA guidelines. They are lands where groundwater is usually at or near the surface, or where the land is covered by shallow water for 7-21 days with primary hydrological indicators present. Wetlands are further defined as lands where saturation with water is the dominant factor determining the nature of soil development and types of plants and animal communities living in the soil or on its surface.

There are a variety of wetlands in Texas. Texas estuarine waters include tidal portions of major rivers, tidal streams, dredged canals, and primary and secondary bays. Playa lakes in the High and Rolling Plains regions of Texas support great numbers of migratory birds in wet years. Forested wetlands cover a wide geographic area in central and eastern Texas.

1.1 Wetland Functions

Wetlands perform many ecologically important functions. These functions vary from wetland to wetland, but include providing water quality protection, flood control, shoreline stabilization, contributions to groundwater and streamflow, and wildlife and fisheries habitat. Wetlands also are valued as natural areas providing aesthetic, recreational, and educational opportunities.

1.1.1 Water Quality Protection

Wetlands improve water quality by three pollutant removal processes: sediment trapping, nutrient removal, and chemical detoxification. Suspended particulate matter and sediments may be deposited when runoff flowing through wetlands is slowed by resistance of plants. Where wetlands precede deeper waters, suspended particulates reaching lakes or streams which could destroy fish spawning habitats by clogging gravel beds may be trapped. Additionally, because many pollutants adsorb to soil particles, the filtering action of the wetland further improves water quality.

Pollutants trapped along with settled soil particles may be buried in the sediments, while others may be converted to less harmful chemical forms by biochemical processes. Still other pollutants may be taken up by plants and either metabolized and recycled within the wetland or transported from it.

Functionally, wetlands also serve as a trap for excess nutrients. An overabundance of nitrogen and phosphorus in surface waters can promote excessive plant and algal growth, resulting in a degradation of water quality. These nutrients accumulate in wetland sediments where they may be converted by microorganisms into forms which are less usable to plants and algae. Other nutrients may be taken up by wetland plants and converted into plant material.

1.1.2 Flood Control

Wetlands have the capacity to store floodwaters, particularly frequently flooded forested areas along rivers, and those with organic soils. During high runoff, these wetland soils temporarily store some of the floodwaters, much as a sponge soaks up water. After the flooding, water is released slowly from the wetlands soils, thus reducing the severity of downstream flooding and erosion. These wetlands also provide flood control along roads. This flood control not only protects the roadway investment but provides a safer driving environment.

1.1.3 Shoreline Stabilization

Vegetated wetlands along shorelines protect against erosion caused by wave action along shores of lakes and estuaries or river currents during floods. Wetland vegetation can absorb much of the energy of the surface waters and binds soil and sediments in its dense root system.

1.1.4 Groundwater Recharge and Streamflow Maintenance

Wetlands can temporarily store water that moves through the underlying soil and enters the local or regional groundwater system. Such movement of surface water into the groundwater system is called groundwater recharge, and occurs when the soil permeability and structure permit.

Water stored in wetlands during wet periods also may be released slowly to adjacent streams during drier periods. This water is important in maintaining streamflows necessary for the survival of animals and other wildlife, fish, plants, and other organisms that live in or near the stream.

1.1.5 Wildlife and Fisheries Habitat

Wetlands provide essential habitat and food for numerous wildlife species of waterfowl, and freshwater and saltwater fish require wetlands for breeding, nesting, or as nursery grounds. About 20 percent of the North American species listed by the federal government as threatened or endangered depend heavily on wetlands (WSDOT, 1994).

This statistic alone often predetermines the final location of highway ROWs in order to minimize impacts to sensitive areas.

Coastal wetlands and some types of inland freshwater marshes exhibit high rates of plant productivity. This high productivity often supports a varied and complex food web both within and outside of the wetland. The role of wetlands in supporting such food webs is of tremendous economic value. Coastal wetlands are considered important sources of nutrients for commercial fish and shellfish. In a 1980 study, the dockside value of estuarine-dependent fish and shellfish caught in U.S. fisheries was reported at over $1.1 billion (WSDOT, 1994). In some cases, commercial shellfish rearing may depend upon adequate maintenance of suitable habitat. Freshwater wetlands are important to commercial fisheries as well, by providing food, habitat, and spawning ground for many species.

1.1.6 Education and Recreation

Because they contain a variety of flora and fauna not found in other environments, wetlands provide unique educational and scientific research opportunities. The diversity of wetland plant life (over 5,000 species nationwide) creates habitats for nearly every form of animal life.

Also, the unknown potential of wetland plants and animals to provide new foods, chemicals, or drugs contributes to the value of wetlands in their natural state. In some cases, control of invasive weeds, such as purple loosestrife, may be of benefit to the preservation of these systems.

An important quality of wetlands is their value as scenic and recreational areas. Recreational use of wetlands is increasing nationwide and includes hiking, boating, fishing, hunting, and wildlife observation.

2.0 Wetland Classification

The United States Fish and Wildlife Service (1979) has developed a wetlands classification system to be used to inventory wetlands and deepwater habitats of the United States. This system is intended to describe ecological taxa and arrange them in a system useful to resource managers; furnish units of wetlands for mapping; and provide uniformity of concepts and terms. Wetlands are defined by plants (hydrophytes), soils (hydric soils), and frequency of flooding.

Highways within Texas are likely to skirt the sensitive areas of streams, lakes, marine, and estuarine wetlands. Bridges may cross these areas but would not provide soil substrate for which weed control would be required. TxDOT vegetation maintenance activities would most likely impact freshwater scrub-shrub or forested wetlands. Impact evaluation of these areas is considered in both the terrestrial and aquatic impact evaluations, as species in these areas will depend upon both terrestrial and aquatic ecosystems.

3.0 Regulation of Wetlands

Although the classification and description of wetlands has been done by USFWS, the US Corps of Engineers has primary responsibility for regulation. For many years wetlands have been regarded as wastelands or idle lands and substantial areas of wetlands have been developed for other purposes such as agriculture and building construction. Impact of highway development and maintenance is likely to be small because permanent wetland areas often occur on terrain or substrate insufficient for highway ROWs. In some cases, highways may actually promote wetland development where roadbed surfaces are elevated and constructed drainage patterns serve as a source of water.

The increased awareness in recent years of the importance of wetlands has led to efforts at all levels of government to protect wetland habitats throughout the United States. A variety of federal, state, and local regulations affect construction and other activities in wetlands and adjacent areas, but the final criterion is “no net loss.”

The principal federal laws that regulate activities in wetlands are Sections 404 and 401 of the Clean Water Act and Section 10 of the River and Harbor Act. Other federal laws include the National Environmental Policy Act, the Coastal Zone Management Act, and a provision of the 1985 Food Security Act known as "Swampbuster." Many of these provisions have defined parameters not only for vegetation management in sensitive areas, but also for the more fundamental issues of highway construction.

TxDOT's memoranda of understanding (MOUs) with the Texas Parks and Wildlife Department and the Texas Natural Resource Conservation Commission provide policy and guidance for the protection and preservation of wetlands, ensuring no net loss of wetlands caused by Department actions, and increasing the quantity and quality of wetlands in the long term. The following are elements of wetland mitigation policy as implemented to varying extents by TxDOT and other state DOTs:

- *Wetland Inventory*: Conduct an inventory of wetlands within and abutting highway ROWs and department-owned capital facilities.

- *Wetland Mitigation Banks*: Develop program and procedures for establishing wetland mitigation banks as mitigation for wetland impacts.

- *Wetland Management Agreements*: Where appropriate and cost-effective, establish cooperative management and maintenance agreements with resource agencies for management of TxDOT-owned wetlands.

- *Wetland Research*: Develop research proposals related to wetlands and transportation. TxDOT has wetland research programs currently underway.

- *Wetland Buffers*: Develop procedures to identify, establish, and protect buffer areas abutting wetlands.

- *Wetland Education Programs*: Develop programs for design, construction, and maintenance personnel on wetland values and department wetland policy. Actively communicate department policy and wetland preservation program to the public.

- *Project Design Alternative Analysis*: Develop project design alternatives that take into consideration public health and safety while avoiding or minimizing direct or indirect impacts to or loss of wetlands.

- *Biology/Wetland Analyses and Reports*: Conduct biology/wetland analyses of projects likely to affect wetlands and develop recommendations for proposed mitigation of wetland impacts. The current impact evaluation provides baseline data for maintenance activities and future decisions.

- *Environmental Documents*: Identify and quantify wetland impacts of alternatives and include a conceptual description of proposed mitigation.

- *Project Design Documents*: Develop project designs which include best management practices, including:

  - Preserving plant life within a wetland;
  - Using native erosion control mixes and plant materials;
  - Treating stormwater runoff through grass swales and sedimentation ponds;
  - Driving piles for bridges or other structures on filter fabric, or trestles to avoid permanent fills in wetlands.

- *Wetland Mitigation Plan*: Develop a wetland mitigation plan to achieve the goal of no net loss of wetland functions and value.

- *Permit Applications*: Incorporate detailed mitigation plan into permit application packages when required if wetlands are affected by proposed future construction or maintenance.

- *Wetland Preservation on Department-Owned Properties*: Develop program and procedures for preserving wetlands on department-owned properties.

- *Wetland Preservation Map*: Designate wetland properties to be preserved and retained in TxDOT ownership on ROW maps/based on USFWS university maps.

- *Disposal Sites*: Develop specifications and manage contracts to ensure sites used by a contractor for disposal of construction material.

- *Drainage Facility Construction*: Develop procedures and specifications to conduct drainage ditches, culvert, and roadside contours for continued flow of water into existing or newly constructed wetlands. Maintenance of these flow conduits may require vegetation control.

- *Pile Driving*: Develop procedures and contract specifications to require pile driving equipment within wetlands to be operated from barges, existing structures, work area platforms on filter fabric, or trestle as approved by permit agencies. Platforms and trestles must be removed after completion of work.

- *Mitigation Implementation*: Highway maintenance shall preserve, protect, and enhance wetlands within highway ROW, and shall avoid adverse impacts unless there is no practical alternative. When maintenance activities result in adverse impacts, the mitigation shall follow a defined order of preference; avoid or minimize impacts, rectify impacts, reduce or eliminate the impact over time, or compensate by replacing, enhancing, or providing a substitute. Department resources and safety of the road user must also be considered.

- *Disposal of Waste Material*: It is a policy of TxDOT to dispose of waste generated from ditch cleaning, pavement sweeping, shoulder repair, or other maintenance activities, in upland sites. Disposal of waste materials in wetlands, either on or off the ROW, is allowed only by permitted action. Disposal of pesticide containers, unused solutions, and spray tank rinsate is performed to comply with regulations and prevent water as well as wetland terrestrial resource contamination.

- *Roadside Management Planning for Protection of Wetlands*: Recognition of wetlands along each roadside is an essential part of the roadside management process and shall be included in roadside management plans along with special management requirements for maintenance and perpetuation of wetlands.

TxDOT wetland mitigation sites may be marked with "No Spraying" signs where roadways abut wetlands. Conditions in wetland environments often are unsuitable for the placement of roadways, so these areas would be avoided when possible.

4.0 Environmental Consequences of Treatment Methods

The potential impacts of roadside pest control methods on wetland habitats and resources would be directly related to any impacts upon water quality. Potential adverse effects include reduced survival or reproduction of aquatic organisms resulting from habitat degradation or toxic effects. These impacts have been evaluated in the aquatic risk assessments reported in other sections of this document.

The quality of wetland habitats depends on hydrology, water temperature, total dissolved oxygen, food supply, protective cover, sediment and nutrient loads, availability of spawning and nursery areas, and the presence of toxic materials. Wetland habitat degradation resulting from increased sediment and nutrient loading is the most likely adverse effect of vegetation control along TxDOT ROWs. Impacts could be caused by any of the identified treatment methods. Effects could include turbidity-induced gill abrasion, covering of spawning habitat, and reduced oxygen levels from the eutrophic effects of increased nutrient loads.

Conversely, noxious weeds which invade and consume wetland areas in the TxDOT-owned ROW corridor may be controlled or eliminated by TxDOT maintenance activities thru proper permit procedure.

4.1 Chemical Techniques

Chemical methods of vegetation management along TxDOT ROWs potentially could have both direct and indirect effects upon wetland habitats and resources. The use of chemical methods would have affect on water quality through accidental direct application, spray drift, or the transport of herbicides and insecticides to surface waters in runoff.

Herbicides and insecticides could be mobilized by surface transport or overland flow, entering surface waters in solution or adsorbed on particulate matter. An aquatic ecological risk assessment is presented in Appendix B, Chapter 2 that describes the potential risks of herbicide-contaminated water to aquatic organisms.

Direct application of herbicides to wetland areas potentially could impact wetland vegetation; thereby degrading many of the functions of a wetland, including water quality protection, flood control, shoreline stabilization, contributions to groundwater and streamflows, and wildlife and fisheries habitat. Direct application of insecticides may affect non-target wildlife species.

Because approximately twenty percent of the North American species listed by the federal government as threatened or endangered depend heavily on wetlands (WSDOE, 1988), any impacts upon wetlands due to herbicide and insecticide application could potentially affect special status species.

However, there currently could be a few aquatic plant species that would be considered pests and controlled only through the use of glyphosate (Rodeo®).

4.2 Cultural Techniques

Cultural techniques generally have a low potential for adversely affecting wetland habitats.

4.3 Biological Techniques

Biological techniques, such as the introduction of pest organisms or the introduction of insects and plant pathogens, likely would not adversely impact water quality. Both of these techniques are species-specific and therefore would very selective. Erosion is not a likely consequence of biological techniques, and non-target effects would be minimal.

4.4 Mechanical Techniques

Mechanical methods, such as mowing, generally have a low potential to impact wetland habitats through soil erosion because they result in substantial retention of soil cover. Grading and discing create a high potential for soil erosion by exposing soil, which would then be carried to aquatic habitats during storm events. Any resulting sedimentation would degrade aquatic habitats.

4.5 Unavoidable Adverse Impacts

Any of the techniques employed for the management of roadside vegetation likely would impact the environment adversely to some degree. As discussed above, the most likely impact is that from soil erosion due to disturbance or elimination of groundcover. In the case of chemical application, some of the chemical potentially could be deposited directly in wetland habitats as a result of spray drift or surface runoff. The degree of impact would be expected to be extremely small and would depend upon the concentration to which desirable organisms would be exposed, the duration of that exposure, and the susceptibility of desirable organisms to the material in question. These risks have been discussed in Appendix B, Chapter 3.

Appendix A - Chapter 7

1.0 Introduction

The native flora of Texas consists of more than 5,000 species. Plant groupings reflect differences in amount and frequency of rainfall, in physical and chemical constituents of soils, and the extremes in temperature. Plant species change continuously from the coastal marshes to the prairies, from the thorny brushlands of South Texas to the grassy plains of North Texas, and from the forests of East Texas to the desert shrublands of West Texas. (See Figure 3-1).

In the following discussions, the concepts of vegetation region and roadside management zone must be maintained as separate entities. A vegetation region is an environmental subsection supporting relatively homogeneous plant communities dominated by a specific group of potential climax plant species. These zones cover thousands of acres, and consequently encompass similar topographic, geologic, soil, and climatic vegetative conditions. The conceptual organization of the ROW into Roadside Management Zones is a grouping of roadside areas (active and passive zones) into units having similar management needs.

The plant community descriptions for each of the vegetation regions refer to relatively undisturbed, long-term, stable, mature, old-growth, or climax conditions. The amount of time required for the plant composition on disturbed sites to stabilize depends on the site; the type, degree and season of disturbance; the seed source for invading plants; and climatic conditions. Plant species considered sensitive by the Texas Parks and Wildlife Department and which would be found growing in the ROW corridor have been listed by vegetational region. While most threatened and endangered plant species would be impacted by disturbance, a few species have been known to thrive on the disturbance.

Highway cut and fill slope construction (Roadside Management Zones 1b and 2, Figure 1-1) generally results in soil conditions unlike any under the original natural vegetation. Therefore, it may be assumed that roadside vegetation would not have the same species composition or productivity as occurs outside the heavily impacted construction zones. Species composition on disturbed areas may be so variable that potential invading species could only be partially assessed through knowledge of the long-term stable community composition and the environmental conditions they require. Species composition in Zones 1b and 2 would be a function of soil condition, selection of seeds to be planted, residual seed at the location, seed sources available in adjacent habitats, and seed transport by vehicular traffic or other vectors from all other areas of the state, as well as other regions of the country.

A list of plant species common names cross-referenced to scientific names is located in Table B7-1.

2.0 Ten Vegetation Regions

Average annual precipitation increases from west to east, ranging from 203-457 mm (8-18 inches) for the Trans-Pecos to 1,016-1,422 mm (40-56 inches) in the Pineywoods (Figure A7-1). The average length of growing season is based on the frost-free period, increasing from north to south. The High Plains' 180-day growing season contrasts markedly with the year-round growing season in the Lower Rio Grande Valley, for example (Figure A7-2). These variations in rainfall and length of growing season would be expressed in the patterns of native vegetation in Texas.

Various combinations of rainfall and temperature result in varying rates of vegetative growth, which affects the degree of control required. The need for vegetation treatment increases markedly from west to east Texas. This climatic variation affects the timing of pesticide application, and may affect the degradation rates of chemicals used.

This section describes the landscape character of the region in terms of geologic history and topography. Major rivers generally run from northwest to southeast. The geology and topography of Texas ranges from relatively flat lands of marine sediments to the east and south through the gently rolling hilly lands in much of the state. Small mountain ranges arose through tectonic activity and mark west Texas, while sizeable water-carved canyons mark portions of north Texas.

2.1 Pineywoods Region

The average annual precipitation is 1,016-1,422 mm (40-56 in), increasing from northwest to southeast. Rainfall tends to be distributed evenly throughout the year. The frost-free period ranges from 235-265 days, increasing from north to south. Average annual temperature is 16-20°C (64-68 °F). The Pineywoods area is a gently to strongly sloping dissected coastal plain. Elevation ranges from 61-213m (200-700 ft), increasing from south to north.

Major Species

The Pineywoods region is characterized by mixed pine-hardwood forest on uplands and mixed hardwood forest on the lowlands. The loblolly, shortleaf, and longleaf pines are native. Slash pine has been introduced successfully on thousands of acres. The region's principal hardwoods would be sweetgum, oak, water tupelo, blackgum, magnolia, elm, maple, walnut, hickory, cottonwood, American beech, ash, and bald cypress.

Many species of shrubs, vines, forbs, and grasses occupy the forest floor, prairies and non-cropland areas. Grasses found in forested areas include blackseed needlegrass, Virginia wildrye, Canada wildrye, purpletop, eastern little bluestem, giant cane, and others. Rosette grasses also could be abundant. Bluestem grasses and forbs dominate the open areas.

Common shrubs and vines occupying the forest floor include the southern wax-myrtle, American beautyberry, grapes, blueberries, hawthorns, greenbriars, rattan vine, trumpet honeysuckle, dewberries, yellow jessamine, and poison-ivy. The area's flowering understory is of note, and includes dogwood, redbud, and black-haw. Forb species include wild indigos, sennas, tickclovers, milkpeas, clovers, vetches, and goldenrods.

Threatened, Endangered and Sensitive Species

Two special status plants, Texas trailing phlox (*Phlox nivalis* ssp *texensis)* and white bladderpod (*Lesquerella pallida*), are found on ROWs in this vegetation region. Special status plants found along TxDOT ROWs are listed in Table A7-2.

Target Vegetation

Vegetation likely to be targeted by pest management along the highway include tall woody species, roadway edge invaders such as johnsongrass, bahiagrass, dallisgrass, and bermudagrass, and excessive growth of vegetation with an affinity for low-lying areas or drainage channels, such as cattails and willows.

2.2 Gulf Prairies and Marshes

The average annual precipitation is 610-1,422 mm (24-56 inches), increasing southwest to northeast. Rainfall peaks in September, with a secondary peak in May. The frost-free period ranges from 245-320 days, increasing from north to south. Average annual temperature is 20-23°C (68-74 °F), increasing from north to south. The Gulf Marshes are low-lying coastal areas frequently covered with saline water, and vary from sea level to a few feet in elevation. The Gulf Prairies are nearly level, largely undissected plains from sea level to an elevation of 76 m (250 ft). Surface drainage is slow.

Major Species

The indigenous plant communities in the Gulf Prairie were tallgrass prairies and post oak savannahs. In recent years, trees such as honey mesquite and acacias have become abundant. Common trees include live oak, post oak, huisache and blackbrush.

Dominant grasses of the Gulf Prairie include gulf cordgrass, big bluestem, little bluestem, eastern gamagrass, gulf muhly, tanglehead, and Indiangrass. Increasing in abundance are invaders such as yankeeweed, broomsedge bluestem, western ragweed, and tumblegrass. Prickly pear is common. Forb species characteristic of the area include asters, Indian paintbrush, poppy mallows, phloxes, bluebonnets, and evening primroses.

Threatened, Endangered and Sensitive Species

Three plant species considered special plant species by the TPWD occur in this region and are found within the TxDOT corridor. These plants are *Ambrosia cheiranthifolia, Hoffmannseggia tenella,* and *Phlox nivalis* subspecies *texensis*. A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Vegetation

Vegetation likely to be affected by vegetation management along the highway includes roadway edge invaders such as bermudagrass and johnsongrass. Tall species such as retama and huisache, and excessive growth by channel-invaders such as cattails may be affected as well.

2.3 Post Oak Savannah

The average annual precipitation is 762-1,143 mm (30-45 inches), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 235-280 days, increasing from north to south. Average annual temperature is 18-21°C (64-70°F). The Post Oak Savannah is characterized by gently rolling and moderately dissected wooded plains. Elevation ranges from 91-244 m (300-800 ft).

Major Species

The vegetation of the Post Oak Savannah is characterized by short oak trees mixed with tall grasses. In the absence of recurring fires, thicketization occurs. Blackjack and post oaks predominate, however, elms, junipers, hackberries, and hickories are numerous. Associated understory shrubs and vines include yaupon, American beautyberry, coralberry, greenbriar, and grapes.

Climax grasses include little bluestem, Indiangrass, switchgrass, silver bluestem, Texas wintergrass, purpletop, narrowleaf woodoats, and beaked panicum. Lower successional species are brownseed paspalum, threeawn, broomsedge bluestem, splitbeard bluestem, rosette grasses, and lovegrasses. Forbs include wild indigo, indigobush, senna, tickclover, lespedezas, prairie-clovers, western ragweed, crotons, and sneezeweeds.

Pasturelands have been seeded with introduced species such as bermudagrass, bahiagrass, weeping lovegrass, and clover.

Threatened, Endangered and Sensitive Species

Only Navasota ladies' tresses (*Spiranthes parksii)* has been found within the TxDOT corridor in this region. A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Vegetation

Vegetation likely to be affected by vegetation management includes tall woody species, excessive cattails in drainage channels, and roadside edge invaders such as johnsongrass and bermudagrass.

2.4 Blackland Prairies

The average annual precipitation is 762-1,143 mm (30-45 in), increasing from northwest to southeast. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 230-280 days, increasing from north to south. Average annual temperature is 18-21°C (64-70 °F). The Blackland Prairie is characterized as a rolling and well-dissected prairie. Elevation ranges from 76-213 m (250-700 ft).

Major Species

The majority of the Blackland Prairie supports true prairie vegetation, while the dominant plant community along major rivers and tributaries is a savannah. Poorly managed lands have sustained brush invasions. The original prairie was dominated by little bluestem, big bluestem, Indiangrass, and tall dropseed. Minor species increasing with grazing pressure include hairy grama, sideoats grama, Texas wintergrass, and buffalograss. Common forbs include asters, prairie bluet, prairie-clover, and late coneflower. Common legumes include snoutbeans and vetch. Poor-condition rangeland and abandoned cropland support mesquite, huisache, oak, and elm species. Oak, elm, cottonwood, and native pecan are common in drainage areas.

Threatened, Endangered and Sensitive Species

No plant species considered special plant species by the TPWD occur in this region. A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Vegetation

Vegetation likely to be targeted by highway vegetation management includes tall species such as mesquite, species with an affinity for low-lying drainage channels such as cattails and willows, and roadside edge invaders such as bermudagrass and johnsongrass.

2.5 Cross Timbers and Prairies

The annual average precipitation is 635-889 mm (25-35 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 230-280 days, increasing from north to south. Average annual temperature is 18-20°C (64-68 °F). The Cross Timbers and Prairies region is characterized by its gently rolling landform. Elevation ranges from 152-457 m (500-1,500 ft) above sea level.

Major Species

The vegetational aspect is one of alternating bands of prairie and woodland. Climax vegetation is dominated by big bluestem, little bluestem, Indiangrass, switchgrass, and Canada wildrye. Secondary species include sideoats grama, blue grama, hairy grama, Texas wintergrass, and buffalograss. These secondary species are increasing with grazing pressure. Invading grass species include hairy tridens, Texas grama, red lovegrass, wild barley, threeawns, fringeleaf paspalum, and tumble windmillgrass. This area contains numerous forbs species such as western ragweed, heath aster, gayfeathers, lespedeza, sageworts, and tephrosias. Upland invaders include such species as scrub oak, mesquite, and juniper, with short- and midgrass understories. Bottomland tree species are primarily hardwoods such as pecan, oak, and elm. Characteristic understory shrubs and vines include skunkbush, saw greenbriar, bumelia, and poison-ivy.

Threatened, Endangered and Sensitive Species

Presently, there are no roadside plant species in this region that have been classified special status by the Texas Parks & Wildlife Department (TPWD). A summary of special status plants found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be targeted by roadside vegetation management includes tall species such as mesquite and excessive vegetation with an affinity for drainage channel growth such as cattails. In addition, roadside invaders such as bermudagrass and johnsongrass may encroach.

2.6 South Texas Plains

The average annual precipitation is 457-762 mm (18-30 in), increasing from west to east. Rainfall peaks in September, with a secondary peak in May. The frost-free period ranges from 260-340 days, increasing from north to south. Average annual temperature is 21-23°C (70-74 þF). The South Texas Plains are characterized by a nearly level to rolling landform. The area is slightly to moderately dissected by intermittent drainageways. Elevation ranges from sea level to 305 m (1,000 ft).

Major Species

The original vegetation of this area was open grassland along the coastal areas and brushy chaparral-grassland in the uplands. Live oak and pecan timber mark the major streams. Originally, thicketization of trees and brushy species occurred only on the upland ridges; however, grazing pressure and the reduction of fires has dramatically altered the vegetation from the original grassland to the woody brush and tree species which now dominate the area. Woody species showing marked increases in this "brush country" include mesquite, live oak, acacia, brazil, spiny hackberry, whitebrush, lime prickly ash, Texas persimmon, and lotebush.

Among the characteristic grasses of the sandy loam soils are seacoast bluestem, bristlegrasses, paspalums, windmillgrass, silver bluestem, big sandbur, and tanglehead. Species often found on the clay soils include silver bluestem, Arizona cottontop, buffalograss, common curlymesquite, and others. Low-lying saline areas may contain gulf cordgrass, seashore saltgrass, alkali sacaton, and switchgrass. Common forbs are prickly pear, orange zexmania, bush sunflowers, velvet bundleflower, tallowweeds, lazy daisies, Texas croton, and western ragweed. Grasses of the oak savannahs are mainly little bluestem, Indiangrass, switchgrass, and crinkleawn. Forbs generally associated with non-saline soils are bush sunflower, orange zexmania, shrubby oxalis, white milkwort, American snoutbean, and greenthread. An introduced tropical species, buffelgrass, is successful in the area. Other introduced species now common on the plains are bermudagrass, kleingrass, rhodesgrass and KR bluestem.

Threatened, Endangered and Sensitive Species

Three plant species considered special plant species by the TPWD occur in this region and are found within the TxDOT corridor. These plants are Johnston's frankenia *(Frankenia johnstonii),* Ashy dogweed (*Thymophylla tephroleuca*) and Tobusch fishook cactus (*Ancistrocactus tobuschii*). A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be affected by vegetation management along the highway includes tall species such as mesquite and huisache and excessive growth by species with an affinity for growing in damp, low-lying drainage channels. Also affected may be roadside invaders such as johnsongrass and bermudagrass.

2.7 Edwards Plateau

The average annual precipitation is 305-813 mm (12-32 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 220-260 days, increasing from north to south. Average annual temperature is 18-21°C (65-70°F). The Edwards Plateau is characterized as a deeply dissected, stony plain with broad and flat to undulating and hilly divides. Hilltops frequently are flat, surrounded by stair-stepped slopes. Elevation ranges from 366-914 m (1,200-3,000 ft) above sea level.

Major Species

The original vegetation on the Edwards Plateau was grassland or open savannah-type plains with trees and brushy species located along stream bottoms and rocky slopes. Tall grasses were previously evenly distributed, but now have been replaced by midgrasses and shortgrasses such as sideoats grama, buffalograss, and Texas grama.

The western part of the area is considerably more arid than the eastern part, and supports short- to midgrass mixed vegetation. The east supports mixed oak savannahs with tall- and midgrasses. The savannahs range from nearly open grasslands with scattered trees to oak stands interspersed with grasses. Climax grasses include cane bluestem, little bluestem, sideoats grama, hairy grama, common curlymesquite, buffalograss, fall witchgrass, and tridens and elymus species. Tobosa grows in mixed stands with Trans-Pecos burrograss. Forbs are in great abundance in the Edwards

Plateau and include Engelmann daisy, orange zexmania, bush sunflower, western ragweed, and sneezeweed. Common on overgrazed land are bitterweed, broadleaf milkweed, smallhead sneezeweed, broomweeds, prairie coneflower, mealycup sage, tasajillo, and prickly pear.

Common woody species include live oak, shinnery oak, post oak, mesquite, and juniper.

Threatened, Endangered and Sensitive Species

Two plant species considered special plant species by the TPWD occur in this region and may be found within the TxDOT corridor. These plants are Tobusch fishhook cactus (*Ancistrocactus tobuschii*) and Texas wild-rice (*Zizania texana*). A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be targeted by vegetation management includes tall species, such as mesquite, and excessive vegetation with an affinity for low-lying drainage channels, such as cattails. Edge invaders, bermudagrass and other perennial grasses, musk thistle and noxious weeds may be affected.

2.8 Rolling Plains

The average annual precipitation is 457-711 mm (18-28 in), increasing from west to east. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 185-235 days, increasing from north to south. Average annual temperature is 13-19°C (56-66 °F). The Rolling Plains area is characterized by a well-dissected, nearly level to rolling plain. Elevation ranges from 305-914 m (1,000-3,000 ft), however, as few of the larger valleys fall substantially below the level of the plain.

Major Species

The original mid- and tallgrass-dominated prairie is undergoing transformation to a community with a mixture of shortgrasses, shrubs, and annuals due to grazing pressures and the reduction of fires.

The tall- and midgrasses of the original prairie include little bluestem, big bluestem, sand bluestem, sideoats grama, Indiangrass, switchgrass, hairy grama, blue grama, Canada wildrye, and western wheatgrass on moister soils. On drier or overgrazed soils, buffalograss, common curlymesquite, tobosa, threeawns, sand dropseed, and hooded windmillgrass are common. Climax forbs include western yarrow, western ragweed, broadleaf mildweed, Lambert crazyweed, prairie coneflower, and slimleaf scurfpea. Western ragweed, annual broomweed, mesquite, lotebush, prickly pear, algerita, and tasajillo are common invaders. Shinnery oak, sand sagebrush, and redberry juniper form dense stands on overgrazed rangeland and abandoned cropland.

Threatened, Endangered and Sensitive Species

One plant, considered a special plant species by the TPWD, is found within the TxDOT corridor in this region. This plant is Texas poppy-mallow (*Callirhoe scabriuscula*). A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be affected by vegetation management includes tall species such as mesquite and excessive growth by vegetation such as cattails which inhabit low-lying drainage channels. Roadside invaders such as wild oat and jointed goatgrass may also be affected.

2.9 High Plains

The average annual precipitation is 356-533 mm (14-21 in), increasing from southwest to northeast. Rainfall peaks in May, with a secondary peak in September. The frost-free period ranges from 180-220 days, increasing from north to south. Average annual temperature is 13-18°C (56-64 °F). The High Plains area is a relatively level plateau which contains two canyons of note, Tule and Palo Duro, along the Caprock Escarpment. There exist many shallow depressions, or playa lakes, which are intermittent in nature and may contain several feet of water and cover as many as 16 ha (40 ac) after heavy rains (TPWD, 1982). The elevation ranges from 914-1,372 m (3,000-4,500 ft).

Major Species

The original vegetation of the High Plains was classified as mixed prairie, shortgrass, and tallgrass prairie. Characteristic on clay soils are blue grama, buffalograss, and galleta. Sandy soils support little bluestem, western wheatgrass, sideoats grama, and sand dropseed. The area is being invaded by sand sagebrush, prickly pear, yucca, and western honey mesquite. Various aquatic species such as curltop smartweed are associated with the playa lakes. Forbs common to the area include slimleaf scurfpea, prairie coneflower, croton, fineleaf woollywhite, woolly loco, plains beebalm, and tallowweed.

Threatened, Endangered and Sensitive Species

There are no roadside plant species in this region that are considered special status by the Texas Parks & Wildlife Department (TPWD). A summary of special status plants found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be targeted by vegetation management along the highway includes tall species such as mesquite only in canyons. Excessive growth by channel-clogging species may be targeted. Wild oat, jointed goatgrass, musk thistle and field bindweed in the ROW may require control.

2.10 Trans-Pecos

The average annual precipitation is 203-457 mm (8-18 in), increasing from west to east and from lower to higher elevations. Rainfall peaks in the period from July through September, with a secondary peak in November. The frost-free period ranges from 220-245 days, increasing from north to south. Average annual temperature is 14-21 °C (58-70 °F), increasing from northeast to southwest and from higher to lower elevations. The Trans-Pecos region is characterized by mountain ranges, rough, rocky land, and flat basins and plateaus. Elevation ranges from 762-2,667 m (2500-8,751 ft), and includes Guadalupe Peak, the highest point in Texas. The region includes the Guadalupe Mountains, Chisos Mountains, and Davis Mountains, in addition to others. Notable canyons occur along the Big Bend of the Rio Grande River and in the Guadalupe Mountains.

Major Species

The original vegetation ranged from desert grassland and desert shrub on lower slopes and elevations to juniper, pinyon pine, and Mexican pinyon at mid elevations. The mountains support ponderosa pine and forest vegetation on the higher slopes. Characteristic species in the basins are creosote bush, tarbush, catclaw acacia, catclaw mimosa, whitethorn, yucca, juniper, and tobosa. Saline soils support alkali sacaton and saltbush species. Characteristic species of the plateaus and canyons are chino grama, leatherstem, ocotillo, candelilla, lechuguilla, and sotols.

Many grass species in the Trans-Pecos region are not present elsewhere in Texas, including Arizona fescue and mountain muhly. Burrograss and fluffgrass have mostly replaced black grama and tobosa. More productive sites have numerous species of grama, muhly, dropseed, and perennial threeawn grasses. At higher elevations, little bluestem, Texas bluestem, sideoats grama, blue grama, pinyon ricegrass, wolftail, and several species of Stipa are common. Poisonous plants are abundant in the area and include threadleaf groundsel, broom snakeweed, rayless goldenrod, lechuguilla, twoleaf senna, and loco.

Threatened, Endangered and Sensitive Species

Four plant species considered special plant species by the TPWD occur in this region and are found within the TxDOT corridor. These plants are Davis' green pitaya (*Echinocerus viridiflorus var. davisii*), Lloyd's mariposa cactus (*Neolloydia mariposensis*), Nellie cory cactus (*Coryphantha minima*), and Lloyd's hedgehog cactus (*Echinocerus lloydii*). A summary of special plant species found along TxDOT ROWs is presented in Table A7-2.

Target Species

Vegetation likely to be targeted by roadside vegetation management include tall woody species such as mesquite and the poisonous African rue. Edge treatments should be made where necessary to control encroaching grasses and forbs, if threatened and endangered plants are not present.

3.0 Noxious Weeds and Other Undesirable Vegetation

3.1 Noxious Weeds

Noxious weeds can be defined as those plant species which would be highly destructive, competitive, or difficult to control by cultural or mechanical practices. Noxious weed infestation from seed produced on roadsides could impact the agricultural economy of the individual enterprise, the local area, and the entire state.

3.2 Other Undesirable Vegetation

A number of other plant species may not be considered noxious weeds but they could become roadside hazards if not adequately controlled. Some of the noxious species and other species that commonly should be controlled include johnsongrass, field bindweed, African rue, huisache, wildoat, and jointed goatgrass. Others include mesquite, retama, cattails, willows, giant ragweed, honey locust, sweetgum, pines and musk thistle.

4.0 Plants Recommended for Establishing Vegetation on Highway Roadsides.

Establishing vegetation on cut and fill slopes, median strips, and other roadside areas disturbed by highway reconstruction or maintenance may be a major factor in the control of unwanted vegetation. Environmental conditions along state highways vary significantly, especially between East and West Texas. The selection of appropriate vegetation will depend on a wide variety of environmental factors, such as temperature, soils, moisture, nutrients, sun exposure, air and water quality, and wind conditions. Vegetation selected for establishment on the ROW should be aesthetically pleasing, ecologically self-sustaining, tolerant of disturbed conditions, and should provide measurable control of surface erosion and unstable slopes.

TxDOT has published a number of guidelines for the selection and establishment of vegetation on Texas highway ROWs. *Standard Specifications for Construction of Highways, Streets and Bridges* (1994) contains in the earthwork section comprehensive guidance comprised of narrative, figures, and tables on such topics as seeding and sodding for erosion control, wildflower seeding, and establishment of roadside plantings. Desirable native and other adapted grasses and legumes have been listed by district, urban and rural conditions, and soil type within the district. Optimal planting periods have been listed as well.

TxDOT's 1993 *A Practical Guide to the Establishment of Vegetative Cover* discusses in more detail the relevant issues, materials, techniques and tools presented in the *Standard Specifications*. It provides practical information for landscape architects, vegetation managers, construction inspectors, maintenance personnel and others involved in establishing a permanent perennial vegetative cover on Texas highways.

Selection of appropriate plants for revegetation should consider the character of the surrounding area (i.e., natural, rural, suburban, and urban), soil conditions, water availability, sun exposure and slope conditions. The size of available space for the plants is also a determining factor in selecting appropriate plants. TxDOT's plant establishment sequence calls for site preparation (tillage to a depth not less than 10.2 cm [4"]), planting a mixture of native and adapted species, and installation of a surface mulch. The emphasis of plant selection for revegetation of disturbed areas is to provide vegetation which would survive with little or no maintenance after the establishment period. TxDOT's specified seed mixes are comprised of species which germinate rapidly and offer good seeding vigor.

5.0 Efficacy of Treatment Methods

5.1 Chemical

*Clopyralid is a selective postemergence, non-crop herbicide for control of broadleaf perennial weeds and woody plants. It is particularly active on plants in the legume

*Undergoing field development; not presently prescribed for use.

(pea) and sunflower families such as vetch, mesquite, and acacias as well as cornflower, thistle, daisy and ragweeds.

Glyphosate is a broad-spectrum postemergence herbicide for control of annual and perennial plants.

Two formulations of glyphosate are available for maintenance use. Roundup® is specified for terrestrial use to control non-crop weeds and grasses. Some of the common species which may be controlled include bermudagrass, foxtail, mustards, morningglory, cheatgrass, groundsel, crabgrass and pigweed. Fortified with Oust®, it may effectively control johnsongrass and other deep-rooted and rhizomatous pest plants. Rodeo® is formulated specifically for aquatic use and treatment of undesirable plants growing in or near water. Bermudagrass, cattails, and willows are common pests in or near standing or flowing water which could be managed using Rodeo®.

*Imazapyr provides preemergence or postemergence plant control with residual control of grasses, forbs, and some woody plants. Postemergence application should be the treatment of choice.

**Hexazinone is a broadspectrum herbicide that controls many annual, biennial, and perennial plants, both herbaceous (except johnsongrass) and woody, in non-crop areas. The mode of action is both contact and systemic. Plant entry is primarily by root uptake, but foliar action is enhanced with surfactants. Hexazinone should not be applied in wet conditions or standing water situations as it moves readily in wet conditions and may affect plants not meant to be controlled.

Metsulfuron methyl is a herbicide which provides both preemergence and postemergence control of woody plants and annual as well as perennial herbaceous weeds. At higher rates it may become nonselective and reduce the growth of bahiagrass and possibly other desirable grasses in noncrop areas. It is effective against mustard, chicory, chickweed, groundsel, mullein, dandelion, prickly lettuce, pigweed, clover, wild carrot, field bindweed, huisache, and african rue.

Sulfometuron methyl is a non-crop herbicide which provides control of annual and perennial grasses and broadleaf weeds as a postemergence or preemergence herbicide. It controls species such as mustard, chickweed, curly dock, prickly lettuce, ragweed, dandelion, clover, kochia, daisy, pepperweed, pigweed, tansy, wild carrot, thistle, groundsel, and mullein. In the TxDOT program it is tank-mixed with glyphosate to extend treatment life and inhibit re-infestation.

**To be removed from approved list when present stocks are exhausted.

Triclopyr is a herbicide recommended for postemergence control of woody plants and annual and perennial broadleaf weeds on noncrop areas. It provides excellent control of certain root-sprouting species. It controls species such as cottonwood, pine, willow, thistle, chicory, curly dock, bindweed, mustard, ragweed, and wild carrot. It controls mesquite when applied to stem bases.

Fenoxycarb has no herbicidal activity. An insecticide, it functions as a growth regulator for the control of fire ants in non-crop, nongrazed areas. It is highly specific to just a few species of ants.

Diazinon has no herbicidal activity. An insecticide, it is used for an alternative treatment of fire ants but has a broad application for other insect pests such as ticks, mites, aphids, webworms, and leaf hoppers.

Chlorpyrifos has no herbicidal activity. It is used primarily as an alternative treatment for control of the fire ant. Cockroaches and crickets also are susceptible.

5.2 Cultural

Cultural techniques for roadside vegetation maintenance utilize highly competitive communities of desirable species to fully occupy the site. Once established, these communities of preferable native and adapted species should fill all available growing sites and maximize the use of soil moisture and nutrients. Weeds and noxious plant populations would be kept at low levels, or often from invading at all, by not having suitable sites for establishment and limited availability of moisture and nutrients required to sustain the vigorous growth needed to out compete the existing vegetation.

Initial establishment of desirable communities on highly disturbed roadside zones could be costly in both time and materials. The use of site preparation techniques, seeding and surface mulching must be coordinated and complement each other. Since weed species would aggressively invade during initial establishment, their exclusion from the original community may require the additional use of chemical or mechanical treatments until the desired vegetation will dominate. Interseeding is a procedure used to augment stands of weak turf or other vegetative cover. Interseeding involves the planting of an approved seed mixture in relatively narrow bands of existing cover. Mulch may or may not be used depending on band width. This process is most successful when spot treatments, either chemical or mechanical, are used to reduce the competitive advantage of any existing undesirable vegetative cover.

Routine maintenance on sites following successful establishment of a desirable native plant community is lower than for invaded sites. Spot treatments, mechanical or chemical, may be needed to arrest small invasions of undesirable plants. Proper selection of original community species should provide the low growth form and soil cover properties which require less mowing. Although they would be more difficult to implement than biological, chemical, or mechanical techniques, the successful application of cultural techniques may be the most efficient and cost-effective treatment for the long-term management of roadside vegetation.

5.3 Biological

Biological control of undesirable roadside species, both plants and animals, is a relatively inexpensive technique to apply, but is still experimental in nature and it generally takes a number of years to effectively produce results. Also, biological controls may be unable to eradicate host species, creating a cyclical pattern of first decreasing host numbers, then decreasing control populations, followed by increasing host species numbers, then by increasing control species. These population swings create a potential for future outbreaks of the host weed species, if anything happens to weaken the control before their populations can regain effective numbers. An additional difficulty with the use of biological agents pertains to roadside conditions. Pest plants rarely are present in large, homogeneous stands ideal for the use of biological agents. This contrasts with some highly effective uses of biological agents in crop situations. ROWs generally have scattered stands of a potentially-targeted pest plant species.

TxDOT's possible experimental biological agents include a seed-boring insect for musk thistle and a seed-eating insect for goathead. One insect undergoing testing as a control for musk thistle, *Hadropluontus trimaculatus,* was found to feed on endangered plant species (USDI, 1991). Unfortunately, the vast majority of Texas invading weed and insect pest species have no known biological controls. These possible agents still are undergoing trial applications, and it is premature to recommend biological controls at this time. They may comprise a portion of the future TxDOT pest management program.

5.4 Mechanical

Mechanical and manual control techniques using tractor- mounted sickle bars, flails or rotatory mowers and hand-operated chainsaws, brush saws or mowers are often used to control small trees, shrubs, and herbaceous vegetation. Repeated cutting of vegetation on medians and side slopes may produce widely variable results, depending on the species being controlled, the methods applied, and the timing.

When shrubs and trees are controlled by mechanical methods they often resprout from roots and root-crowns, creating higher plant stem densities than before control. Many shrubs and resprouting tree species respond most vigorously after above-ground material has been removed during the dormant season. These species often produce more and bigger stems, limbs, and suckers than if they were not pruned at all. Mechanical vegetation control measures must be applied in a manner that most adversely affects the target species. Proper timing and application of treatment is critical, otherwise removal of regrowth may be required two or more times per year.

6.0 Environmental Consequences of Treatment Methods

Maintaining plant communities having the desired growth characteristics for roadside safety and aesthetics, that require low maintenance, mitigate erosion, encourage wildlife use in appropriate areas, and provide storm runoff biofiltration capacity while not greatly impeding flows, is the ultimate goal of roadside vegetation management. Vegetation management techniques available to create the desired conditions may be in the form of chemical, cultural, biological, or mechanical treatments. Each of these has widely varying costs, both financial and environmental, that often change from district to district and even between vegetation regions within one district.

Vegetation responses to roadside management programs could only be assessed in this document in a very generalized manner. Evaluation of vegetation responses to management programs must be addressed as a specific analysis of site/species/disturbance relationships on each individual project. Every combination of trees, shrubs, forbs, and grasses respond to treatment in a different manner. The variation in response is often increased when native and exotic species have been intentionally planted along ROWs. The plant community response, as opposed to individual species responses, often depends upon climate; species composition, dominance, and phenology; treatment type and degree; and situation properties and conditions.

Particular attention must be paid to vegetation control measures being inadvertently applied to threatened, endangered, or sensitive species or to native plant communities of concern. In areas of highly intensive agricultural activity, sometimes the only remaining examples of individual species or high quality native plant communities can be found in Zone 2, between the actively managed road system and the annually disturbed agricultural fields. The Natural Heritage Program of the Texas Parks and Wildlife Department should be consulted on all projects involving potential disturbance of native plants or plant communities containing threatened and endangered plants. A listing of sensitive species found along TxDOT ROWs appears in Table A7-2.

Even though vegetation management programs should be specific, environmentally similar sites usually can be expected to respond to treatments in a similar manner.

This section discusses the broad implications of four different management techniques on roadside vegetation within Texas. Besides the no vegetation management option, there are four other vegetation management methods consisting of chemical, cultural, biological, and mechanical techniques for controlling undesirable vegetation and for creating or enhancing desirable vegetation.

6.1 No Vegetation Management Activities

If no vegetation management activities were used to control roadside vegetation, nature would take its course. The natural biological requirements of plants provides them with highly competitive niches. Under this alternative, any native or exotic plant species which can be established in direct competition with other plants should grow unimpeded by management activities.

The changes within a plant community brought about by the ability of one plant to become dominant over others on a site is called succession. Over time, vegetation develops along normal successional lines. The highway ROW has areas where soil has been disturbed during construction (Zone 1b) and areas where soil may or may not have been disturbed (Zone 2). On sites where some topsoil remains or has been replaced following construction, desirable native species may be established rapidly. If not controlled, the highly disturbed areas of ROW (cut and fill slopes of bare soils) could revert to early successional plant communities composed of weedy annual and perennial grass and forb species. On sites where upper soil horizons have been removed, a community of pioneer species may dominate the disturbed site for a period of time. Areas where the native soils remain intact should proceed along the successional line and reach a given climax vegetation community more quickly than highly disturbed areas.

Succession is a long-term phenomenon. Plant communities may require decades to move from one successional stage to another. TxDOT's specified seed mixtures compress successional time, especially if seeding is combined with some chemical and mechanical site preparation treatments.

A no-action approach to roadside vegetation management is undesirable because of the need to meet highway safety and other ROW requirements. Under the no action option, native and exotic weedy vegetation may establish in and dominate areas of ROW that are bare of vegetation. Weed dominance on ROWs may result in creating an attractant for undesirable insect populations and diseases. This then creates another problem if it occurs adjacent to large scale agricultural operations. Although most agricultural pests are controlled directly on the crop, removal of additional repositories, such as ditches and ROWs, may offer an effective and economical control of these pests.

6.2 Chemical Techniques

Herbicides can be used to remove or retard undesirable vegetative growth on ROWs. An effective strategy would be to use herbicides to improve the potential competitive edge of desirable vegetation. Herbicide usage involves selection of the best chemical, careful application, utilizing phenology of target and non-target plants, considering environmental constraints, incorporating safety precautions, and anticipating the potential for off-site impacts.

Herbicides used by TxDOT range from broadspectrum treatments to highly selective foliar-applied chemicals that target relatively narrow groups of broad-leaved forbs, shrubs, and trees. Where desirable vegetation is established on slopes and medians, spot treatment of individual weeds or small, localized populations using selective herbicides can be very effective for maintaining and enhancing the growth of desirable vegetation.

The impacts of chemical treatments vary depending on how closely the target and non-target species are related, the selectivity of the herbicide, and the application method, timing and rate. Populations of annual plants generally are more sensitive to herbicides than are perennials, especially if treated during an early stage of development. Annual and perennial weed species which have occupied a site for several years often have large seed reserves in the upper soil horizons and may require repeated application of control measures until the majority of weed seeds have germinated and highly competitive, desirable vegetation has become established on the site.

Although it is the least expensive treatment in terms of labor, materials and equipment, chemical control of vegetation sometimes may result in high environmental costs. Rainfall following treatment or misapplication of herbicides along road edge, ditch, and backslopes may result in contamination of stormwater runoff and non-target areas. Poorly planned or executed herbicide applications could remove or damage both desirable and undesirable vegetation.

6.3 Cultural Techniques

Cultural techniques may be used to establish highly competitive, stable, native or naturalized plant communities in order to meet TxDOT roadside vegetation management goals. This approach entails site preparation, seeding, and surface mulching, interseeding areas of thin cover, and other efforts focused on enhancing the health and competitive ability of desirable plants. Establishment of native species generally creates plant communities having resistance to native insect and disease problems, and provides a vegetative cover that is well adapted to local conditions. Establishment, enhancement, and maintenance of native grasses, legumes, and wildflowers should be an integral phase of roadside vegetation management.

6.4 Biological Control

The experience of Washington State DOT shows that biological control with host-specific foraging insects could be somewhat effective in controlling some species in Washington. Unfortunately, no effective biological controls presently exist for the vast majority of insect pests and noxious weed species on Texas ROWs.

Biological treatment with species-specific insects or pathogens should have no adverse impacts on non-target plants. All insects and pathogenic organisms used in biological control must be evaluated for host-specificity by the United States Department of Agriculture, Animal and Plant Health Inspection Service, prior to authorizing release of the agent into the environment. There is great complexity involved in application of biological controls. Environmental tolerances of both the plants to be controlled and the biological control vectors often do not overlap exactly.

Although biological control techniques often take more time and may require repeated applications to establish insect or pathogen populations which can effectively control the target pest, they are the least expensive to implement of all control techniques. Often no predator is known for a problem plant in Texas. Most stands of pest plants on the ROW may be too small for treatment to be considered feasible. The establishment and management of stable, desirable plant communities through biological control of a single undesirable plant species may result in reduced need for more disruptive types of vegetation control in the future. Over the long-term this strategy may reduce maintenance costs.

6.5 Mechanical Control

Tractor-mounted sickle bars and flail or rotary mowers can be used to control small trees, shrubs, and herbaceous vegetation. Repeated close mowing of grass and forb species on medians and sideslopes could weaken the plants and mechanically affect the soil surfaces. Operation of even light-weight tractor-mounted mowers on wet, fine-textured soils can remove vegetative cover which allows for invasion of undesirable species, or compact subsurface soil layers, leading to surface erosion or slumping of soils.

Grass-forb communities, a major component of the roadside vegetation in many areas, remain in best health when allowed to complete their natural life-cycle of flowering and late-summer/fall maturing. Frequent mowing to create the appearance of a lawn reduces vigor of many grass species and removes flowers before seeds mature fully. Late-blooming wildflowers would not produce flowers, whereas dormant-season mowing of standing mature vegetative material can aid the spread of seeds and incorporation of organic matter into the generally poor roadside soils and maintain the integrity of wildlife habitat. Dry season operation and use of low ground-pressure maintenance equipment should mitigate possible soil disturbance from mechanical vegetation control.

Selection and scheduling of the best mechanical method for treating vegetation in a particular roadside location depends on the following:

1. Characteristics of the plant species to be removed (e.g.,stem size and density, brittleness, resprouting ability, and phenologic stage of growth);

2. Characteristics of the plant species to be enhanced or established (e.g., need for seedbed preparation and natural versus planted revegetation);

3. Roughness or steepness of topography and terrain;

4. Soils characteristics (e.g., type, depth, amount and size of rocks, erosiveness, moisture content, and susceptibility to compaction);

5. Climatic conditions; and

6. Other values such as habitat or aesthetics.

Manual methods for managing vegetation could also be considered mechanical techniques. Hand tools and hand-operated power tools may be used to cut, clear, or prune vegetation, generally above ground level, to enhance site conditions for desired plants. Due to the scale of TxDOT projects, this control method is relegated for use where other treatments are not feasible or mechanized equipment cannot operate safely.

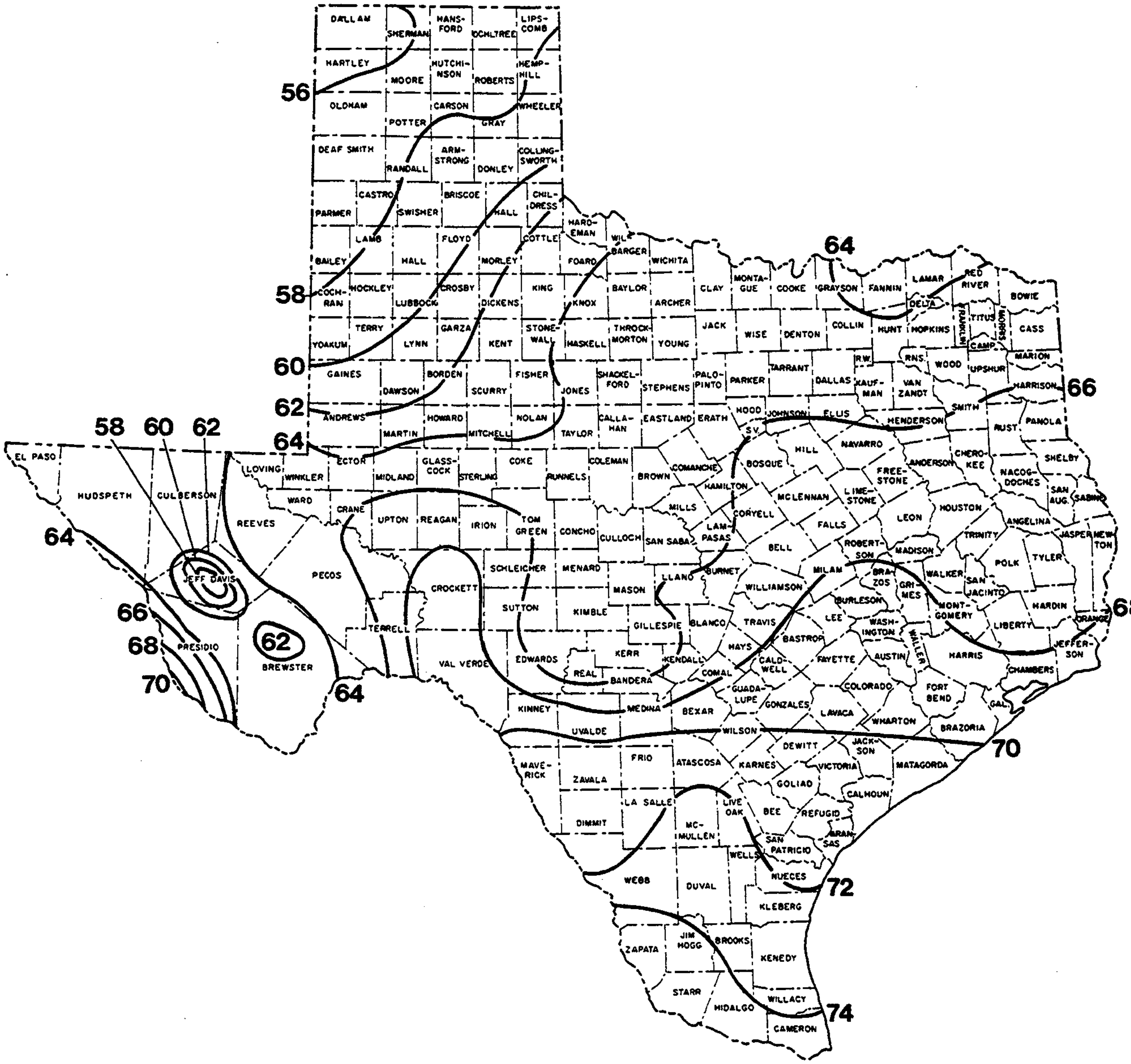
Site disturbance is minimal with manual techniques. However, manual techniques would not be expected to affect the composition of a plant community. Pulling or digging out a plant's root system to prevent sprouting and regrowth is not feasible on a paved shoulder, may be extremely difficult in the highly-compacted soils of the active zone (Zone 1b), and is labor-intensive.

Shrubs and trees controlled by manual methods often may resprout from roots and root-crown, creating higher plant stem densities than existed before control. Proper timing of manual control treatment is critical; otherwise, removal of regrowth may be required two or more times per year. Other than for roadside areas infested with small populations of a noxious weed, forbs and grasses generally would be too numerous to be controlled efficiently by this technique.

Most grass and forb species maintain best health and vigor when allowed to complete their natural life-cycle of vegetative growth, flowering, seed maturing, and late-summer/fall die-back. Many shrubs and resprouting tree species respond most vigorously after pruning has occurred during the dormant season. Many species often produce more and bigger stems, limbs, and suckers than if they were not pruned at all. Manual vegetation control measures should be applied to most adversely affect the undesirable species.

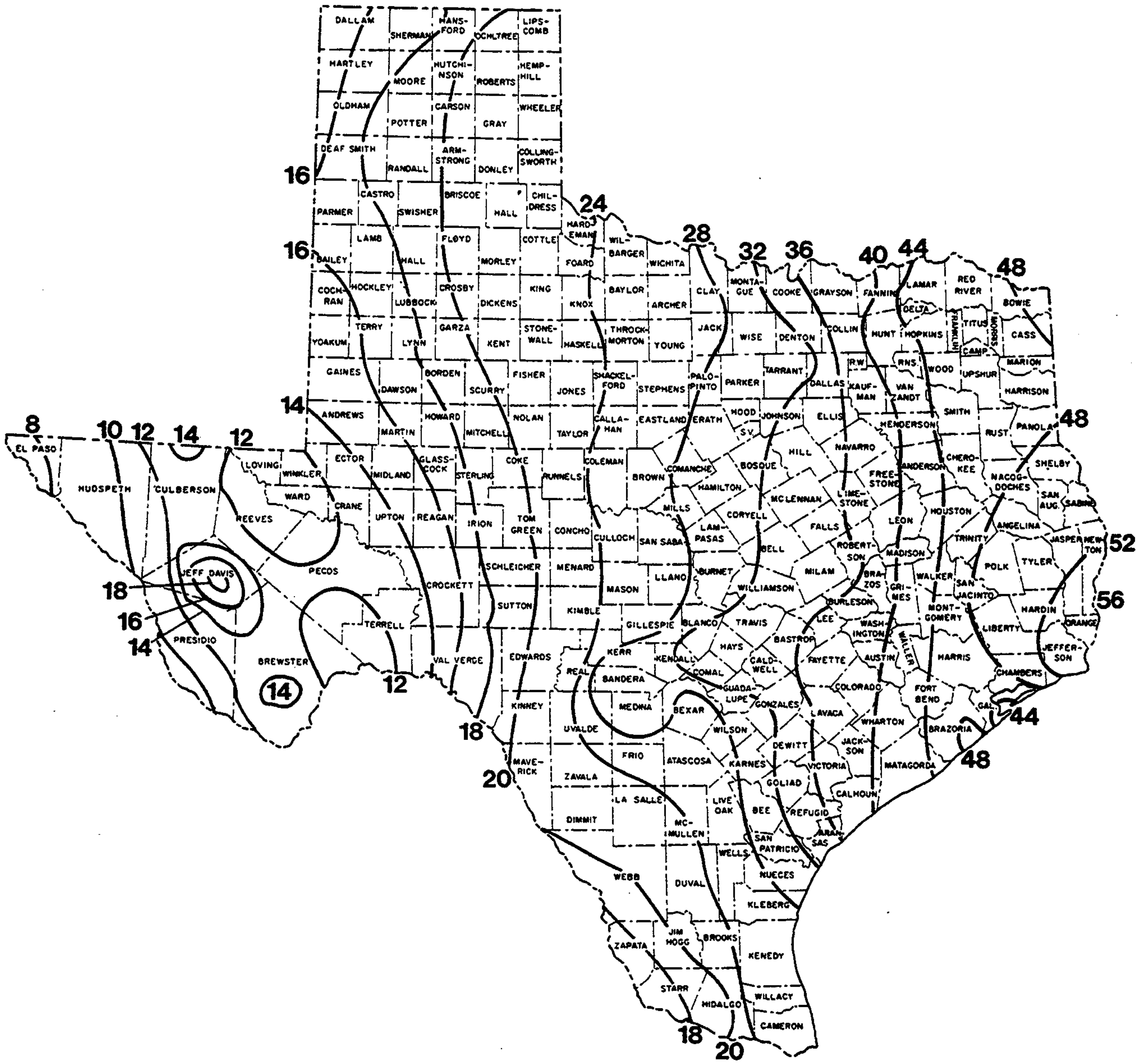
Manual control appears to be the most costly vegetation control technique available due to the labor-intensive work, the potential need to visit a site at different times to treat different species, and the often marginal results in controlling regrowth. The application of manual control is desirable, though, since it could be highly selective of undesirable species or individual plants. Desirable species would be beneficially affected through minimal exposure to disturbance and reduced competition from target species for nutrients, water, and space. Effectiveness of this control technique would not vary greatly with its application in different vegetation regions throughout Texas.

Figure A7-1. Mean Annual Temperatures in Texas (°F)



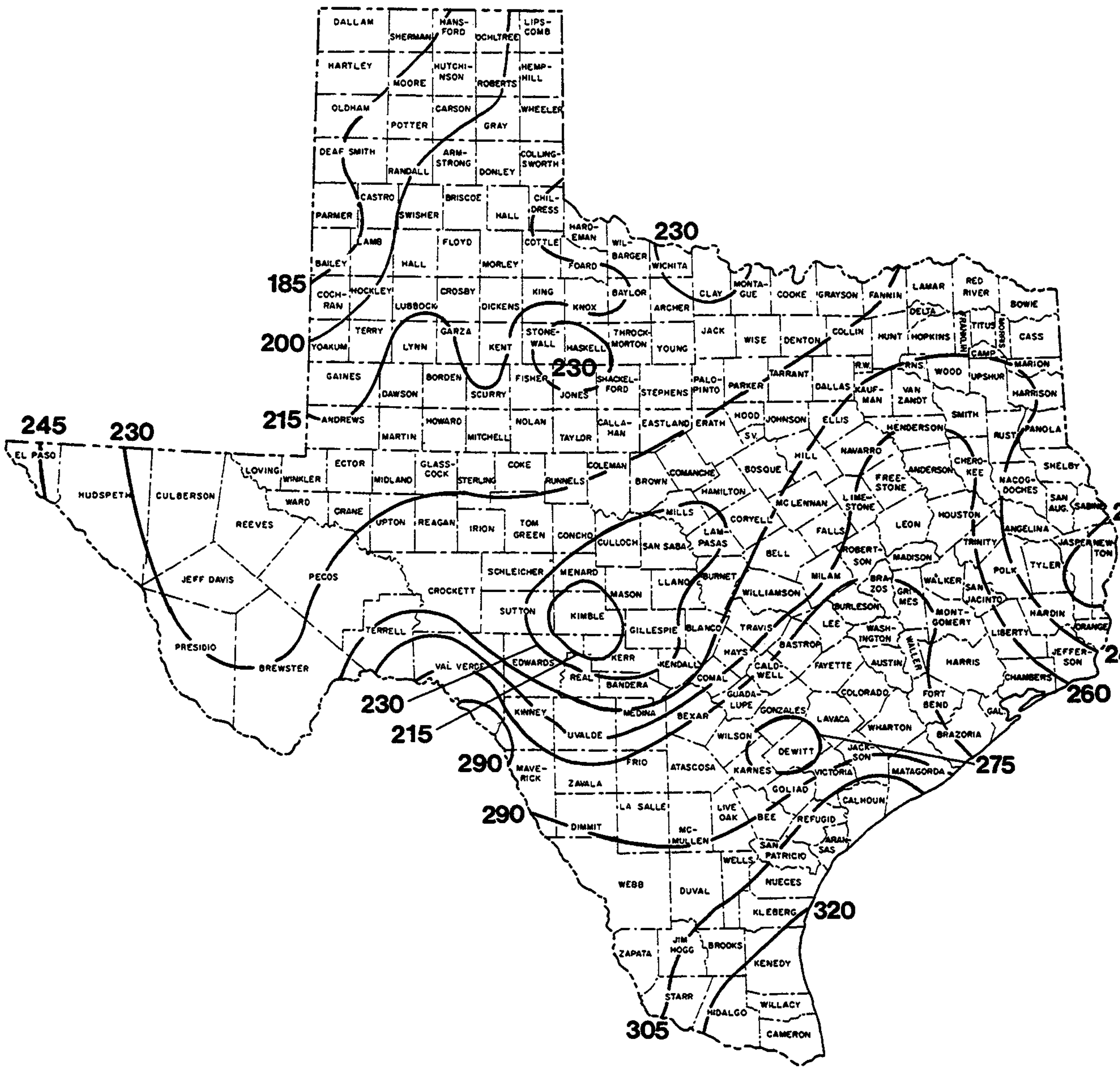
Source: Hatch et al., 1990.

Figure A7-2. Mean Annual Precipitation in Texas (inches)



Source: Hatch et al., 1990.

Figure A7-3. Mean Length of Frost-Free Period in Texas (days)



Source: Hatch et al., 1990.

Table A7-1. Cross Reference of Common Name to Scientific Name for Plant Species Discussed in this Chapter

Common Name **Grasses**	Scientific Name
Arizona fescue	*Festuca arizonica*
Bahiagrass	*Paspalum notatum*
Beaked panicum	*Panicum anceps*
Bermudagrass	*Cynodon dactylon*
Big bluestem	*Andropogon gerardii*
Blackseed needlegrass	*Piptochaetium avenaceum*
Blue grama	*Bouteloua gracilis*
Broomsedge bluestem	*Andropogon virginicus*
Brownseed paspalum	*Paspalum plicatulum*
Buffalograss	*Buchloe dactyloides*
Buffelgrass	*Cenchrus ciliaris*
Burrograss	*Scleropogon brevifolius*
Eastern gamagrass	*Tripsicum dactyloides*
Eastern little bluestem	*Schizachyrium scoparium*
Fall witchgrass	*Digitaria cognata or Panicum spp.*
Fluffgrass	*Dasyochloa pulchella*
Fringeleaf paspalum	*Paspalum setaceum var.ciliatifolium*
Galleta	*Hilaria jamesii*
Giantcane	*Arundinaria gigantea*
Gulf cordgrass	*Spartina spartinae*
Gulf muhly	*Muhlenbergia filipes*
Hairy grama	*Bouteloua hirsuta*
Hairy tridens	*Erioneuron pilosum*
Indiangrass	*Sorghastrum nutans*
Jointed goatgrass	*Triticum cylindricum*
King Ranch (KR) bluestem	*Bothriochloa ischaemum*
Kleingrass	*Panicum coloratum*
Narrowleaf woodoats	*Chasmanthium sessiliflorum*
Pinyon ricegrass	*Piptochaetium fimbriatum*
Purpletop	*Tridens flavus*
Red lovegrass	*Eragrostis secundiflora*
Rhodesgrass	*Chloris gayana*
Rosettegrass	*Dichanthelium spp.*
Seacoast bluestem	*Schizachyrium littorale*

Table A7-1. Cross Reference of Common Name to Scientific Name for Plant Species Discussed in this Chapter (continued)

Sideoats grama	*Bouteloua curtipendula*
Silver bluestem	*Bothriochloa saccharoides*
Splitbeard bluestem	*Andropogon ternarius*
Stipa spp.	*Stipa spp.*
Switchgrass	*Panicum virgatum*
Tall dropseed	*Sporobolus asper*
Tanglehead	*Heteropogon contortus*
Texas grama	*Bouteloua rigidiseta*
Texas wintergrass	*Stipa leucotricha*
Threeawn spp.	*Aristida spp.*
Tobosa	*Hilaria mutica*
Tumblegrass	*Schedonnardus paniculatus*
Tumble windmillgrass	*Chloris verticillata*
Virginia wildrye	*Elymus virginicus*
Weeping lovegrass	*Eragrostis curvula*
Western wheatgrass	*Elytrigia smithii*
Wild barley	*Hordeum vulgare*
Wild oat	*Avena fatua var fatua*
Wolftail	*Lycurus phleoides*

Forbs

Aster spp.	*Aster spp.*
Bluebonnet	*Lupinus spp.*
Bluet	*Hedyotis spp.*
Clover spp.	*Trifolium* spp.
Coneflower	*Dracopis spp. or Ratibida spp.*
Croton	*Croton spp.*
Evening Primrose	*Oenothera spp.*
Gayfeather	*Liatrus spp.*
Goathead	*Tribulus terrestris*
Goldenrod	*Soldiago spp.*
Greenthread	*Thelesperma ambiguum*
Heath aster	*Aster ericoides*
Indian paintbrush	*Castilleja indivisa*
Indigo	*Indigofera spp.*
Indigobush	*Amorpha fruticosa*
Lazy Daisy	*Aphanostephus spp.*
Lespedezas	*Lespedeza spp.*

Table A7-1. Cross Reference of Common Name to Scientific Name for Plant Species Discussed in this Chapter (continued)

Littlesnout sedge	*Carex microrhyncha*
Lythrum salicaria	
Milkpea	*Galactia spp.*
Musk thistle	*Carduus nutans*
Orange zexmenia	*Zexmenia spp.*
Phlox	*Phlox spp.*
Poppy mallow	*Callirhoe spp.*
Prairie clover	*Dalea spp.*
Prickly pear	*Opuntia spp.*
Purple Loosestrife	*Lyricum salicaria*
Sagewort	*Artemisia spp.*
Senna spp.	*Senna spp.*
Shrub oxalis	*Oxalis berlandieri*
Sneezeweed	*Helenium spp.*
Tallowweed	
Tephrosia	*Tephrosia spp.*
Texas croton	*Croton texensis*
Tickclover	*Desmodium spp.*
Velvet bundleflower	*Desmanthus velutinus*
Vetch spp.	*Vicia spp.*
Western ragweed	*Ambrosia cumanensis*
White milkwort	*Polygala alba*
Yankeeweed	*Eupatorium compositifolium*

Shrubs

American beautyberry	*Callicarpa americana*
Blueberries	*Vaccinium spp.*
Bumelia	*Bumelia spp.*
Candelilla	*Euphorbia antisyphilitica*
Catclaw acacia	*Acacia greggii*
Catclaw mimosa	*Mimosa spp.*
Coralberry	*Cocculus carolinus or Symphoricarpos orbiculatus*
Creosote bush	*Larrea tridentata*
Dewberry	*Rubus spp.*
Grape spp.	*Vitis spp.*
Greenbriar	*Smilax spp.*

Table A7-1. Cross Reference of Common Name to Scientific Name for Plant Species Discussed in this Chapter (continued)

Hawthorn	*Crataegus spp.*
Leatherstem	*Jatropha dioica*
Lechuguilla	*Agave lecheguilla*
Lotebush	*Zizyphus obtusifolia*
Ocotillo	*Fouquieria splendens*
Poison ivy	*Toxicodendron radicans*
Prickly pear	*Opuntia spp.*
Rattan vine	*Berchemia scandens*
Saltbush	*Atriplex spp.*
Sand sagebrush	*Artemisia filifolia*
Skunkbush	*Rhus flabelliformis*
Sotol	*Dasylirion spp.*
Tarbush	*Flourensia cernua*
Trumpet honeysuckle	*Lonicera sempervirens*
Wax-myrtle	*Myrica heterophylla*
Yaupon	*Ilex vomitoria*
Yellow jessamine	*Gelsemium spp.*
Yucca	*Yucca spp.*
Trees	
Acacia spp.	*Acacia spp.*
Alder spp.	*Alder spp.*
American beech	*Fagus grandifolia*
Ash spp.	*Fraxinus spp.*
Bald cypress	*Taxodium spp.*
Blackbrush	*Acacia rigidula*
Black gum	*Nyssa sylvatica*
Black haw	*Viburnum prunifolium*
Blackjack oak	*Quercus marilandica*
Brasil	*Condalia hookerii*
Cottonwood	*Populus deltoides*
Dogwood	*Cornus drummondii*
Elm spp.	*Ulmus spp.*
Hackberry	*Celtis laevigata*
Hickory spp.	*Carya spp.*
Huisache	*Acacia smallii*

Table A7-1. Cross Reference of Common Name to Scientific Name for Plant Species Discussed in this Chapter (continued)

Juniper spp.	*Juniperus spp.*
Lime pricklyash	*Zanthoxylum fagara*
Live oak	*Quercus virginiana*
Loblolly pine	*Pinus taeda*
Longleaf pine	*Pinus palustris*
Magnolia	*Magnolia spp.*
Maple spp.	*Acer spp.*
Mesquite	*Prosopis glandulosa*
Oak spp.	*Quercus spp.*
Pecan	*Carya illinoiensis*
Pinyon pine	*Pinus edulis*
Post oak	*Quercus stellata*
Ponderosa pine	*Pinus ponderosa*
Ratama	*Parkinsonia aculeata*
Redberry juniper	*Juniperus pinchotii*
Redbud	*Cercis canadensis*
Sand shinnery oak	*Quercus havardii*
Shortleaf pine	*Pinus echinata*
Slash pine	*Pinus elliottii*
Spiney hackberry	*Celtis pallida*
Sweet gum	*Liquidambar styraciflua*
Texas persimmon	*Diospyros texana*
Walnut spp.	*Juglans spp.*
Water tupelo	*Nyssa aquatica*
Whitebrush	*Aloysia gratissima*

Table A7-2. Threatened and Endangered Plant Species found along TxDOT ROWs

TxDOT District	County	Plant Species (scientific name)	Plant Species (common name)
Austin	Hays	*Zizania texana*	Texas wild-rice
Beaumont	Hardin	*Phlox nivalis, subspecies texensisle*	Texas trailing phlox
Bryan	Brazos	*Spiranthes parksii*	Navasota ladies'tresses
Corpus Christi	Nueces & Kleberg	*Ambrosia cheiranthifolia*	South Texas ragweed
		Hoffmannseggia tenella	Slender rush-pea
El Paso	Brewster	*Echinocerus viridiflorus var. davisii*	Davis' green pitaya
		Neolloydia mariposensist	Lloyd's mariposa cactus
		Coryphantha minima	Nellie cory cactus
Laredo	Kinney & Val Verde	*Ancistrocactus tobuschii*	Tobusch fishhook cactus
Lufkin	San Augustine	*Lesquerella pallida*	White bladderpod
Odessa	Pecos	*Echinocerus lloydii*	Lloyd's hedgehog cactus
Pharr	Starr &	*Frankenia johnstonii*	Johnston's frankenia
	Zapata	*Thymophylla tephroleuca*	Ashy dogweed
San Angelo	Kimble	*Ancistrocatus tobuschii*	Tobusch fishook cactus
	Runnels	*Callirhoe scabriuscula*	Texas poppy-mallow

Source: Dennis Markwardt, TxDOT.

Table A7-3. List of Grasses and Legumes Used by TxDOT to Establish Vegetative Cover on ROWs

Scientific Name	Common Name	Comments
Agropyron smithii (Ag-ro-PIE-ron SMITH-e-i)	Western Wheatgrass	A **native, cool-season perennial bunch grass** which spreads through underground stems (rhizomes) and from seed. Typically produces a seedhead in June and goes dormant in mid-summer. This species does best on low areas of heavy soils where runoff water accumulates. It spreads slowly but cannot thrive under heavy mowing operations.
Andropogon hallii (An-dro-PO-gon HALL-e-i)	Sand Bluestem	A **native, warm-season perennial bunch grass** which spreads by seed and rhizomes. Typically produces a seedhead in August to October. It grows best on loamy to sandy soils. An excellent grass species for the more arid portions of the State. Can withstand closer mowing than some of the other bunch grasses.
Avena sativa (Ah-VEE-na Sah-TEE-vuh)	Oats	An **introduced, cool-season annual bunch grass** used for temporary erosion control.
Bothriochloa ischaemum (Both-ree-o-KLO-uh Ish-ee-mum)	K.R. Bluestem	A **native, warm-season perennial bunch grass** which is leafy and deep-rooted. It prefers medium fine-textured soils, but does well on sandy soils as well. Best sources indicate the species was introduced into California from China in 1917, but was not noticed until 1937 on the King Ranch (hence the name).
Bouteloua curtipendula (Boo-teh-LOU-uh Kur-teh-PEN-dew-luh)	Sideoats Grama	A **native, warm-season perennial bunch grass** which spreads from rhizomes. Typically produces a seedhead during June through September which is 18 to 36 inches in height. It grows on well drained areas, shallow ridges and rocky areas, but can be found on soils ranging from deep to very shallow. It will gradually decrease if mowed closer than 2 to 3 inches during the growing season. **State grass of Texas!**
Bouteloua eriopoda (Boo-teh-LOU-uh Ear-e-PO-duh)	Black Grama	A **native, warm-season perennial bunch grass** which produces a seedhead from June through October. Typically found from south-central Texas, into the Panhandle and into West Texas. Works well on dry slopes and plains.
Bouteloua gracilis (Boo-teh-LOU-uh GRASS-uh-lis)	Blue Grama	A **native, warm-season perennial bunch grass** which grows erect in definite bunches and reproduces only by seed. A short species which typically grows only from 10 to 20 inches high. The mature seedhead usually forms a curve which resembles the human eyebrow. Withstands extreme drought conditions. Will decrease when mowed below 3 inches during the growing season. Widely adapted to different soils types including alkaline soils.
Buchloe dactyloides (BOO-klo-uh Dak-tee-LOY-dees)	Buffalograss	A **native, warm-season, perennial, sod-forming (turf) grass** that reproduces by seed and vigorous surface runners (stolons). Low growing species seldom more than 5 inches tall. Withstands close mowing well, however it is more vigorous when mowed higher than 3 inches. An excellent species especially in those areas which are not sandy.

Source: *A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-Way, 1993.*

Table A7-3. List of Grasses and Legumes Used by TxDOT to Establish Vegetative Cover on ROWs (continued)

Scientific Name	Common Name	Comments
Cenchrus ciliaris (SIN-kruhs Sil-e-AIR-is)	Buffelgrass	An **introduced, warm-season, perennial bunch grass** common on sandy soils amd semi-disturbed sites in the South Texas Area. Produces seed from early spring till late autumn under favorable growing conditions.
Cynodon dactylon (SI-no-dun DAK-te-lawn)	Bermudagrass	An **introduced, warm-season, perennial sod-forming (turf) grass** which spreads primarily by above ground stems (stolons), but also by seed and by rhizomes. An excellent, all-around turfgrass which grows throughout Texas on any moderately well-drained soil, whether acid or alkaline, provided adequate moisture and food are present.
Eragrostis trichodes (Err-uh-GRAUS-tes Tri-KOY-dees)	Sand Lovegrass	A **native, warm-season, perennial bunch grass** which spreads by seed and sometimes by rooting at the nodes of the base stems. It is a tall plant with seedheads from 2 to 5 feet produced in the early fall. Produces a dense deep root system. Grows best on sandy soils but can often be found on heavier soils. This species decreases rapidly when mowed closer than 5 inches.
Festuca arundinaceae (Fes-TOO-kuh A-RUN-di-NAY-cee)	Tall Fescue	A **native, cool-season, agressive, perennial bunch grass** which grows to a typical height of 3 to 4 feet. It spreads by tillering (short shoot development) which develops a uniform thick sod. It has a heavy, fibrous root system which pene-trates the soil as much as 5 feet.
Hordeum vulgare (HOR-de-um Vul-GAR-e)	Barley	An **introduced, cool-season annual bunch grass** used for temporary erosion control.
Leptochloa dubia (Lep-toe-KLO-uh DOO-be-uh)	Green Sprangletop	A **native, warm-season, tufted perennial bunchgrass** with a firm base but without stolons or rhi-zomes. Produces a seed head during May to November. A very important element in our seed mix because it serves as a **nurse grass** for all the other warm-season perennial seed species. It's primary purpose is to provide initial erosion-control stabilization and cover and to modify the seedbed so that the other species can grow and flourish. Normally exists for only two growing seasons.
Panicum virgatum (PAN-uh-kum Vur-GATE-um)	Switchgrass	A **native, warm-season, perennial bunchgrass** with vigor-ous roots which spreads from rhizomes and from seed. Best adapted to lower areas of moist soils, but is winter-hardy and drouth-resistant. It decreases under heavy mowing closer than 5 inches.
Paspalum notatum (Pas-PAY-lum No-TAUT-um)	Bahiagrass	An **introduced, warm-season, dense, tufted perennial bunchgrass** that grows from 1 to 2½ feet tall. Spreads by seed and also vegetatively by short, heavy runners. Forms a dense, heavy sod even on droughty, sandy soils. Adaptive to both heavy and sandy soils.
Schizachyrium scoparium (Shi-ZAH-uh-kree-um Sko-PAIR-e-um)	Little Bluestem	A **native, warm-season, perennial bunchgrass** which grows from 2-4 feet tall. Produces a seedhead from August to December. Decreases with heavy mowing. **Insure that seed furnished was of Texas origin only.**

Source: *A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-Way, 1993.*

Table A7-3. List of Grasses and Legumes Used by TxDOT to Establish Vegetative Cover on ROWs (continued)

Scientific Name	Common Name	Comments
Setaria italica (See-TAIR-e-uh I-TAL-i-kuh)	Foxtail Millet	An **introduced, warm-season annual bunchgrass** used for temporary erosion control.
Sorghastrum avenaceum (Sor-GAS-trum A-vee-NAY-ce-um)	Indiangrass	A **native, warm-season, perennial bunchgrass** which spreads both from seed and from short underground rhizomes. Produces tall (4-8 feet) seedheads. Decreases under mowing closer than 5 inches. May form patches of sod and may also occur in bunches. Readily establishes in disturbed sites.
Sporobolus cryptandrus (Spor-ROB-o-lus Krip-TAN-drus)	Sand Dropseed	A **native, warm-season perennial bunchgrass** that grows in rather small tufts or bunches. It spreads from seed and the old bunches spread by tillering. Growth begins in early spring and seed heads appear about September on stems 1 to 3 feet tall. Grows well on sandy, open soils. Moves in quickly on disturbed soils. Although it has very tiny seed (5,000,000+ per pound), many of the seed are "hardseed" and do not germinate well unless softened by acid or scarifying.
Triticum aestivum (TRIT-ih-kum Ess-TEE-vum)	Wheat	An **introduced, cool-season annual bunch grass** used for temporary erosion control.
Trifolium incarnatum (Tri-FO-le-um In-kar-NAY-tum)	Crimson Clover	An **introduced, cool-season legume** used for temporary erosion control. Provides the added benefit of beautiful red seedheads.
Melilotus officinalis (Mel-ih-LO-tus O-FISH-e-uh-nal-is)	Yellow Sweetclover	An **introduced, cool-season legume** used for temporary erosion control.
Chloris guyana (KLO-ris GUY-an-uh)	Rhodesgrass	An **introduced, warm-season perennial bunchgrass** with stems growing from a leafy base. Often spreads by long stolons which root at the leafy nodes. Grows on bottomlands.
Setaria macrostachya (See-TAIR-e-uh MAK-ro-STACH-ya)	Plains Bristlegrass	A **native, warm-season bunchgrass** which normally displays a pale green color. Grows in open, dry ground.
Vicia villosa (VEESH-e-uh Vih-LO-sa)	Hairy Vetch	An **introduced, cool-season legume** used for temporary erosion control.

Source: *A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-Way, 1993.*

Table A7-4. Illustration of Seeding Specifications for District 1 (Partial Listing for Illustrative Purposes)

		Mixture for Clay or Tight Soils				Mixture for Sandy Soils	
Dist	Dates	(Eastern Sections)		(Western Sections)		(All Sections)	
1	Feb 1 to May 15	Green Sprangletop	0.9	Green Sprangletop	0.7	Green Sprangletop	1.1
		Bermudagrass	1.2	Bermudagrass	0.9	Bermudagrass	1.5
		Little Bluestem	1.7	Little Bluestem	1.4	Bahiagrass	6.7
		Indiangrass (Lometa)	2.3	Indiangrass (Lometa)	1.8	(Pensacola)	===
			===	Switchgrass (Alamo or Blackwell)	1.4		
					===		
		Total:	6.1	**Total:**	6.2	**Total:**	9.3

URBAN AREA WARM-SEASON SEEDING RATE: In Pounds, Pure Live Seed (PLS)

		Mixture for Clay or Tight Soils		Mixture for Sandy Soils	
Dist	Dates	(All Sections)		(All Sections)	
1	Feb 1 to May 15	Green Sprangletop	1.7	Green Sprangletop	1.7
		Bermudagrass	2.3	Bermudgrass	2.3
			===		===
		Total:	4.0	**Total:**	4.0

TEMPORARY COOL-SEASON SEEDING RATE: In Pounds, Pure Live Seed (PLS)

Dist	Dates	(All Sections)	
1	Aug 15 to Nov 30	Tall Fescue	4.0
		Western Wheatgrass	5.0
		Wheat (Red, Winter)	30.0
			====
		Total:	39.0

TEMPORARY COOL-SEASON LEGUME SEEDING RATE: In Pounds, Pure Live Seed (PLS)

Dist	Dates	(All Sections)	
1	Aug 15 to Nov 30	Crimson Clover	7.0
			===
		Total:	7.0

Source: *A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-Way*, 1993.

Table A7-5. List of Wildflower Species Used by TxDOT on ROWs

Chart

The following chart lists various wildflower species according to their flowering period. The chart also provides the colors of each flower and the region(s) of the state where each variety thrives. The numbers listed under region correspond to the numbered areas on the map following this chart.

Flowering Period and Species	Flower Color	Region
February - July		
Winecup *(Callirhoe involucrata)*	Reddish Purple	1-10
February - August		
Coreopsis *(Coreopsis cardaminefolia)*	Yellow, Red, Brown	2, 4, 6-10
February - November		
Lazy Daisy *(Aphanostephus skirrhobasis)*	Yellow	2-10
Cut-Leaf or Engelmanndaisy *(Engelmannia pinnatifida)*	Yellow	2-10
February - December		
Slender Vervain *(Verbena halei)*	Rose, Lavender, Blue	1-10
Plains Coreopsis *(Coreopsis tinctoria)*	Yellow, Red, Brown	1-5, 7-10
Firewheel *(Gaillardia pulchella)*	Red, Yellow, Brown	2-10
March - May		
Spider Lily *(Hymenocallis liriosme)*	White	1-3
Prairie Paintbrush *(Castilleja purpurea)*	Yellow, Green	4, 5, 7, 8
Fragrant Gaillardia *(Gaillardia suavis)*	Yellow, Orange, Red	2, 4-10
March - July		
Pink Evening-Primrose *(Oenothera speciosa)*	White, Pink, Rose	1-8, 10
Meadow Pink *(Sabatia campestris)*	Lilac, Rose, Pink	1-9
March - September		
Sweet Sand-Verbena *(Abronia fragrans)*	White, Pink	5, 8-10
March - November		
Mexican Hat *(Ratibida columnaris)*	Yellow, Brown	1-10
Mealy Blue Sage *(Salvia farinacea)*	Violet-Blue	4-8, 10
March - December		
Annual Sunflower *(Helianthus annuus)*	Yellow, Brown	1-10

Source: *Roadside Vegetation Management: A Volume of the Infrastructure Manual,* 1993.

Table A7-5. List of Wildflower Species Used by TxDOT on ROWs (continued)

Flowering Period and Species	Flower Color	Region
April - May		
Downy Phlox *(Phlox pilosa)*	Rose Pink	1-5
Blue-Eyed Grass *(Sisyrinchium ensigerum)*	Blue, Violet	2, 4, 5, 7-10
April - June		
Yarrow *(Achillea millefolium)*	Yellowish White	1-5, 7-10
Coral-Bean *(Erythrina herbacea)*	Scarlet	1-3, 6
April - August		
Fluttermill *(Oenothera missouriensis)*	Yellow	2, 4, 5, 7-9
April - September		
Grenthread *(Thelesperma simplicifolium)*	Yellow, Red	4-8, 10
Butterflyweed *(Asclepias tuberosa)*	Red-Orange	1-10
April - October		
Prickly Poppy *(Argemone albiflora)*	White	1-7
Lemon-Mint *(Monarda citriodora)*	White, Pink	1-10
Rayless Greenthread *(Thelesperma megapotamicum)*	Yellow, Red	4, 7-10
May - June		
Clasping Coneflower *(Rudbeckia amplexicaulis)*	Yellow, Red	1-8
Texas Paintbrush *(Castilleja indivisa)*	Red, Orange	1-7
Foxglove *(Penstemon cobaea)*	White, Lavender	1-8
May - August		
Spotted Beebalm *(Monarda punctata)*	White, Yellow	1-10
May - September		
Blueweed *(Helianthus ciliaris)*	Yellow	2, 5-10
May - October		
Tahoka Daisy *(Machaeranthera tanacetifolia)*	Lavender, Yellow	8-10
May - November		
Brown-Eyed Susan *(Rudbeckia hirta)*	Yellow, Brown	1-9
Blue Sage *(Salvia azurea)*	Deep Blue	1-5, 7-9
May - December		
Cardinal Flower *(Lobelia cardinalis)*	Deep Red, White	1-9
Spring - Fall		
Penstemon species	Scarlet, White, Lavender, and Pink variations	All regions except Rio Grande Valley

Source: *Roadside Vegetation Management: A Volume of the Infrastructure Manual,* 1993.

Table A7-5. List of Wildflower Species Used by TxDOT on ROWs (continued)

Flowering Period and Species	Flower Color	Region
June - August		
Pink Vervain *(Verbena pumila)*	White	5-10
June - September		
Blue Bell *(Eustoma grandiflorum)*	Blue, Purple	2-10
July - September		
Giant Goldenrod *(Solidago gigantea)*	Yellow	1, 3-5, 7-10
July - October		
Maximilian Sunflower *(Helianthus maximiliani)*	Yellow	2-5, 7-9
Goldenrod *(Solidago radula)*	Yellow	1-5, 7
August - October		
Goldenrod *(Solidago altissima)*	Yellow	1-5, 7, 9, 10
* Snow-on-the-Mountain *(Euphorbia marginata)*	Green, White (Leaves are showy part of plant)	1, 2, 3, 4
August - December		
Gayfeather *(Liatrix mucronata)*	Lavender, Purple	2-8
Year Round		
Dakota Vervain *(Verbena bipinnatifida)*	Pink, Purple	1-10
Drummond Phlox *(Phlox drummondii)*	Red, Pink, Purple	2-7
Dandelion *(Taraxacum officinale)*	Yellow	2, 4, 7-10
Spring - Summer		
* Partridge Pea *(Cassia fasciculata)*	Yellow	1-9
* Illinois bundleflower *(Desmanthus illinoensis)*	Yellow	1-9
* White Sweetclover *(Melilotus alba)*	White	3-9

* Denotes legumes.

Source: *Roadside Vegetation Management: A Volume of the Infrastructure Manual,* 1993.

Appendix A - Chapter 8

Draft EIS

Pest Management Program

1.0 Introduction

The environmental parameters which contribute to the wide variety of plant species also provide a wide variety of wildlife habitats. While a number of different wildlife communities can be found throughout the state, they are not as closely related to the natural regions as are plant groups. In East Texas, wildlife communities adapted to the uplands and bottomlands of a mixed -species forest are present. This is contrasted with the desert habitats and the associated wildlife typical of many parts of west Texas. Given this diversity of wildlife and wildlife habitats, it is important that each of these regions be addressed separately in order to examine the unique conditions and concerns for each of these provinces. A complete species inventory of terrestrial and aquatic wildlife, and fish resources, complete with their habitat preference, is beyond the scope of this environmental impact statement. Major species are listed, especially those of commercial and recreational importance, and those which are threatened or endangered.

Texas designations for endangered, threatened, and sensitive wildlife species are summarized in Table A8-2. Also included is the designation by United States Fish and Wildlife Service for these species. This information is based on the most current published status list at the time of the EIS preparation. References used to develop the list include 50 CFR 17.11 and 17.12, *Endangered and Threatened Wildlife and Plants,* April 15, 1990; *Animal Notice of Review* (50 CFR 17), January 6, 1989; and Sections 65.1710 - 065.177 and 65.1810 - 0184 of Title 31 of the Texas Administrative Code; and Chapters 67 and 68 of the Texas Parks and Wildlife Code(TPW); and additions to date in the *Texas Register*. Current status should always be confirmed with a local Texas Parks and Wildlife Department representative.

Endangered species - Any species that is seriously threatened with extinction throughout all or a significant portion of its range in Texas.

Threatened species - Any species that is not presently endangered but could become so in the foreseeable future.

Sensitive species - Those species classified as endangered, threatened, or candidate species.

Candidate species - Any species for which the TPWD or USFWS has substantial information to support the biological appropriateness of proposing to list as endangered or threatened but has not yet listed (C1) or any species awaiting more information before listing (C2).

The first part of this chapter presents a regional overview of Texas wildlife species and habitats, including a description of federal and state listed threatened and endangered species. The second part of this chapter examines the effects of roadside vegetation management on Texas wildlife resources. The discussion of environmental consequences focuses on the habitat effects resulting from chemical, cultural, biological, and mechanical treatments. Toxicological effects on wildlife are addressed separately in Appendix B, Chapter 2.

2.0 Terrestrial Wildlife and Wildlife Habitat

The vegetational regions (Figure 3-1) of Texas encompass a broad range of environmental features and conditions, providing habitat for more than 1,100 species of mammals, birds, reptiles, and amphibians. General habitat and wildlife characteristics of these zones are described below by vegetational regions. Many species of wildlife tend to be site specific in occurrence, and they probably are restricted through plant (food preference) or regional association.

2.1 Pineywoods

The Pineywoods supports a wealth of wildlife species in its upland and bottomland forests, and in its streams, and lakes. Small mammals which forage on the ground include raccoon, pocket gopher, eastern mole, California jack rabbit, eastern cottontail, and several species of shrews, rats, wood rats, mice, and skunks. White-tail deer inhabit the area. Gray and fox squirrels and eastern flying squirrel nest and forage in the forest canopy. Mammalian predators include the opossum, weasel, mink, bobcat, gray fox, coyote, and red wolf. Several species of bats inhabit the area. Armadillos are ubiquitous, and aquatic mammals such as swamp rabbit, muskrat, nutria, and river otter can be found largely in river bottoms.

The Pineywoods region is recognized as one of several critical wintering ranges for North American waterfowl in the Central Flyway. The forested wetlands in the area serve as breeding range for resident wood ducks and wintering range for mallards and other important waterfowl species. Common non-migratory birds include red-tailed hawks, black and turkey vultures, killdeer, and least sandpipers, and several species of woodpeckers and warblers. The pine and hardwood forest canopies support a myriad of small birds species such as chickadees, titmice, wrens and swallows. The brown thrasher and several species of thrushes forage on the forest floor.

Common amphibians are salamanders, toads, and tree frogs. Common reptiles include alligators, box and water turtles, lizards, skunks, and many species of snakes.

Threatened and Endangered Species

Texas provides habitat for almost 150 animals formally listed as threatened or endangered by the Texas Parks and Wildlife Department and/or U.S. Fish and Wildlife Service (see Table A8-2). Threatened and endangered species inhabiting or known to migrate through the Pineywoods include: Eastern big-eared bat, Reddish egret, Whooping crane, American swallow-tailed kite, Arctic peregrine falcon, Bald eagle, Piping plover, Interior least tern, Red-cockade woodpecker, Bachman's sparrow, Alligator snapping turtle, Northern scarlet snake, Timber rattlesnake, Smooth green snake, Louisiana pine snake, Texas horned lizard, Paddlefish, Bluehead shiner, Blue sucker, Creek chubsucker, Blackside darter.

2.2 Gulf Prairies and Marshes

Wildlife in the Gulf Prairies and Marshes includes small mammals such as raccoon, skunk, pocket gopher, California jack rabbit, Ord kangaroo rat, and the eastern cottontail, all of which forage in the grasslands and thickets. Several species of rats, mice, shrews, squirrels, bats, and the eastern flying squirrel inhabit the area as well. White-tailed deer are common in the region. Mammalian predators include coati, weasel, mink, badger, gray fox, and coyote. The wetlands accommodate aquatic mammals such as the swamp rabbit, river otter, muskrat, beaver, and nutria.

The Gulf Prairies and Marshes region is recognized as one of the most important waterfowl areas in North America, as winter waterfowl concentrations in this region exceed any other geographical unit in the Central Flyway. Approximately 50 percent of ducks and 75 percent of geese in North America depend on this coastal habitat. Summer residents which breed in the area include herons, egrets, some species of spoonbill and ibis, mottled ducks, gulls, and five species of terns. The oaks provide nesting sites for cuckoos, woodpeckers, wrens, northern mockingbirds, northern cardinals, and scissor-tailed flycatchers. Seaside sparrows and red-winged blackbirds nest in the marsh grasses and cattails.

Amphibians common in the region are salamanders, frogs, tree frogs, and toads. Common reptiles include alligators, box and water turtles, many species of sea turtles in coastal areas, and snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Gulf Coast Marshes and Prairies include: Eastern big-eared bat, Blue whale, Finback whale, Black right whale, Pygmy killer whale, Short-finned pilot whale, Pygmy sperm whale, Dwarf sperm whale, Gervais' beaked whale, Killer whale, Sperm whale, False killer whale, Atlantic spotted dolphin, Rough-toothed dolphin, Manatee, Goose-beaked whale, Reddish egret, Whooping crane, Brown pelican, White-faced ibis, White-tailed hawk, American swallow-tailed kite, Northern aplomado falcon, Arctic peregrine falcon, Bald eagle, Piping plover, Eskimo curlew, Least tern, Interior least tern, Sooty tern, Attwater's prairie chicken, Loggerhead sea turtle, Green turtle, Leatherback sea turtle, Atlantic hawksbill sea turtle, Hawksbill sea turtle, Kemp's ridley sea turtle, Texas scarlet snake, Black-striped snake, Timber rattlesnake, Speckled racer, Smooth green snake, Texas horned lizard, Black-spotted newt, Houston toad, White-lipped frog, Mexican tree frog, Paddlefish, Blue sucker, Creek chubsucker, River goby, Blackfin goby, Opposum pipefish.

2.3 Post Oak Savannah

The Post Oak Savannah provides prairie, thicket, and bottomlands habitats for numerous wildlife species. Small mammals which forage on the ground include raccoon, pocket gopher, and eastern cottontail. Numerous species of shrews, mice, pocket mice, skunks, rats, and wood rats inhabit the area as well. The gray and fox squirrels and eastern flying squirrel nest and forage in tree canopies. Bats are common. White-tailed deer are numerous. Mammalian predators include the weasel, mink, coyote, red wolf, red and gray foxes, and bobcat. River bottomlands provide aquatic habitat for swamp rabbits, beaver, and nutria.

The Post Oak Savannah provides numerous waterfowl habitats around man-made reservoirs, small flood-control wetlands, and farm and ranch ponds. Wood ducks are known to breed in this region. Coots, pintail, and teal are common. Quail and mourning doves are popular game birds in the Post Oak Savannah. Other common birds include the eastern bluebird, eastern phoebe, and numerous woodpeckers, chickadees, titmice, wrens and sparrows. The northern cardinal, northern mockingbird, and blue jay are abundant, and vultures and owls are found in the region as well.

Common amphibians include many species of toads, salamanders, frogs, and tree frogs. Common reptiles include alligators, box and water turtles, lizards, skunks, and many species of snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Post Oak Savannah include: Eastern big-eared bat, Reddish egret, White-faced ibis, American swallow-tailed kite, Arctic peregrine falcon, Bald eagle, Piping plover, Interior least tern, Sooty tern, Timber rattlesnake, Texas horned lizard, Houston toad, Shovelnose sturgeon, Blue sucker, Creek chubsucker, Blackside darter.

2.4 Blackland Prairies

The Blackland Prairies support many wildlife species. Small mammals which forage on the ground include raccoon, thirteen-lined ground squirrel, pocket gopher, California jack rabbit, and eastern cottontail. White-tailed deer are common. The region supports a number of species of shrews, moles, skunks, mice, and rats. Fox and the eastern flying squirrel nest in tree canopies. Predatory mammals include ringtail, weasel, red and gray foxes, red wolf, coyote, and bobcat. Aquatic mammals include swamp rabbits and nutria.

This region provides important waterfowl habitat around man-made reservoirs, small flood control wetlands, and numerous farm and ranch ponds. Ducks and geese reach peak numbers during winter migrations. Mourning dove, bobwhite quail, and numerous songbirds inhabit the area. Other common birds include owls, woodpeckers, purple martins, northern mockingbirds, northern cardinals, boat-tailed grackles, and vultures.

Common amphibians include several species of salamanders, toads, spadefoot toads, frogs, and tree frogs. Common reptiles are the box and water turtles, lizards, skunks, and many species of snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Blacklands include: Eastern big-eared bat, Reddish egret, White-faced ibis, American swallow-tailed kite, Arctic peregrine falcon, Bald eagle, Piping plover, Interior least tern, Sooty tern, Timber rattlesnake, Texas horned lizard, Comal blind salamander, Texas blind salamander, Blanco blind salamander, Houston toad, Shovelnose sturgeon, Blue sucker, Creek chubsucker, Blackside darter.

2.5 Cross Timbers and Prairies

The Cross Timbers and Prairies support many wildlife species. Small foraging mammals include the eastern mole, little short-tailed shrew, raccoon, thirteen-lined ground squirrel, black-tailed prairie dog, pocket gopher, eastern cottontail, California jack rabbit, and armadillo. White-tailed deer are common. Several species of skunks, mice, and rats inhabit the area as well. Predatory mammals include opossum, weasel, mink, coyote, red wolf, and bobcat. Aquatic mammals include swamp rabbits, nutria, and muskrat. The Georgia and red bats are found in the region.

The Cross Timbers and Prairies is recognized as an important waterfowl habitat. Its reservoirs, wetlands, and farm and ranch ponds consistently support large concentrations of mallards and Canada geese. Quail, mourning dove and wild turkey are common. Other birds found in the region include meadowlarks, warblers, cedar waxwings, loggerhead shrike, and northern mockingbirds. Sandpipers, hermit thrushes, American robins, scissor-tailed flycatchers, and chickadees, titmice, and wrens are abundant. Owls and vultures are common as well.

Common amphibians include several species of salamanders, toads, frogs, and tree frogs. Common reptiles include turtles, lizards, skunks, and snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Cross Timbers include: Texas kangaroo rat, White-faced ibis, American swallow-tailed kite, Arctic peregrine falcon, Bald eagle, Brazos water snake, Texas horned lizard, Shovelnose sturgeon, Blue sucker, Blackside darter.

2.6 South Texas Plains

The South Texas Plains support numerous wildlife species, including small foraging mammals such as opossum, eastern mole, Mexican and spotted ground squirrels, fox squirrels, South Texas and chestnut-faced pocket gophers, Ord kangaroo rat, California jack rabbit, and eastern cottontail. Several species of shrews, skunks, mice, bats, and rats occupy the region as well. Predatory mammals include badger, opossum, weasel, coyote, cougar, and bobcat. Mammals found in or near aquatic habitat include nutria and beaver. White-tailed deer and javelina are common native big game species. Exotic game species are increasing in number.

The South Texas Plains represent the northernmost distribution of many sub-tropical birds found on the North American continent. Many species common to this region are found nowhere else in the United States. Common species include the least grebe, white-winged and mourning doves, woodpeckers, flycatchers, long- and curve-billed thrashers, cactus wren, eastern screech owl, roadrunners, tufted titmouse, and olive sparrows. Inca doves, white-necked ravens, black-throated sparrow, and verdin are common in the Falcon State Recreation Area. Quail and wild turkey are gamebirds common throughout the region. Common amphibians include the tiger salamander, toads and spadefoot toads, tropical frogs, and tree frogs. Common reptiles include several species of box and water turtles, the Texas banded gecko, lizards, skunks, and many species of snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the South Texas Plains include: Southern yellow bat, Coue's rice rat, Ocelot, Jaguarundi, Black bear, Reddish egret, Whooping crane, White-faced ibis, White-tailed hawk, Northern gray hawk, American swallow-tailed kite, Northern aplomado falcon, Arctic peregrine falcon, Ferruginous pygmy-owl, Cactus ferruginous pygmy-owl, Bald eagle, Texas botteri's sparrow, Northern beardless tyrannulet, Tropical parula, Texas scarlet snake, Black-striped snake, Indigo snake, Speckled racer, Northern cat-eyed snake, Reticulated collared lizard, Texas horned lizard, Black-spotted newt, Rio Grande lesser siren, Sheep frog, White-lipped frog, Mexican burrowing toad, Mexican tree frog, Blue sucker, River goby, Blackfin goby, Opposum pipefish.

2.7 Edwards Plateau

The Edwards Plateau supports a variety of wildlife species adapted to the semiarid environment. Small foraging mammals include raccoon, eastern mole, coati, Mexican ground squirrel, rock squirrel, Botta and chestnut-faced pocket gophers, banner-tailed and Loring kangaroo rats, porcupine, California jack rabbit, eastern cottontail, and armadillo. The area is known for its sizeable bat population. Numerous species of mice, rats, shrews, and skunks inhabit the area. Predatory mammals include the weasel, mink, ringtail, badger, opossum, red and gray foxes, coyote, red wolf, cougar, and bobcat. Aquatic mammals include beaver, nutria, and muskrat. The Edwards Plateau contains the largest white-tailed deer population in North America. Deer and javelina are popular native big game species in the region. Exotic big game species such as axis, sika, and fallow deer and blackbuck antelope are becoming increasingly important to the region.

Quail, mourning dove, and turkey are common game birds in the Edwards Plateau. Rock and inca doves, greater roadrunners, belted kingfishers, cliff swallows, and ladder-backed woodpeckers all are common to the region. Herons, vultures, and red-tailed hawks are abundant, as are meadowlarks, chickadees, wrens, titmice, and sparrows.

Common amphibians are the salamander, toad, and the tropical and tree frogs. Common reptiles include box and water turtles, the Texas banded gecko, and numerous species of lizards and snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Edwards Plateau include: Mexican long-nosed bat, Black bear, Whooping crane, White-faced ibis, White-tailed hawk, Northern gray hawk, American swallow-tailed kite, Northern aplomado falcon, Arctic peregrine falcon, Ferruginous pygmy-owl, Cactus ferruginous pygmy-owl, Bald eagle, Sooty tern, Texas botteri's sparrow, Northern beardless tyrannulet, Golden-cheeked warbler, Rose-throated becard, Tropical parula, Black-capped vireo, Concho water snake, Texas lyre snake, Reticulated gecko, Texas horned lizard, San Marcos salamander, Comal blind salamander, Texas blind salamander, Blanco blind salamander, Mexican stoneroller, Proserpine shiner, Devil's River minnow, Blue sucker, Widemouth blindcat, Toothless blindcat, Leon Springs pupfish, Conchos pupfish, Pecos pupfish, Clear Creek gambusia, Fountain darter, Rio Grande darter.

2.8 Rolling Plains

The intermixing of rangeland and cropland provides habitat for numerous species in the Rolling Plains region. Small foraging mammals include the eastern mole, raccoon, the thirteen-lined ground squirrel, Mexican ground squirrel, spotted ground squirrel, black-tailed prairie dog, fox squirrel, pocket gopher, Ord kangaroo rat, California jack rabbit, eastern cottontail, and several species of shrews, skunks, mice, and rats. Predatory mammals include the opossum, weasel, mink, badger, red fox, coyote, cougar, and bobcat. Beaver is found in river bottomlands. Popular big-game species include pronghorn, mule deer, and white-tailed deer.

This region is recognized as a critical terminus in the Central Flyway. Hundreds of thousands of geese and ducks including mallards, pintails, and teal winter in the Rolling Plains. Playa lakes, man-made reservoirs, and stock ponds could be surrounded by vast acreages of winter wheat and other grain crops, providing excellent migratory waterfowl habitat. Mourning dove, quail, and wild turkey are other popular game birds found in this region. Other species common to the Rolling Plains include Bewick's and rock wrens, brown towhee, rufous-crowned sparrow, red-tailed and Swainson's hawks, American kestrel, Mississippi kite, osprey, and golden eagle. Canyon species include golden-fronted and ladder-backed woodpeckers, rock dove, scrub jay, tufted titmouse, bushtit, and canyon wren.

Common amphibians include the tiger salamander, spadefoot toads, and a few species of frogs. Common reptiles include the red-eared turtle, greater earless lizard, Texas spiny lizard, skunks, and many snake species.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Rolling Plains include: Texas kangaroo rat, Palo Duro mouse, Arctic peregrine falcon, Bald eagle, Interior least tern, Brazos water snake, Texas horned lizard, Blue sucker.

2.9 High Plains

Small foraging mammals include eastern mole, Crawford shrew, thirteen-lined ground squirrel, black-tailed prairie dog, fox squirrel, chestnut-faced pocket gopher, Ord kangaroo rat, California jack rabbit, and eastern cottontail. Several species of skunks, mice, rats inhabit the area. Predatory mammals include opossum, weasel, badger, coyote, and bobcat. Muskrat is found in playa wetlands and river bottomlands. Exotics provide hunting in the area.

The playa lakes, man-made reservoirs, and stock ponds in the High Plains region often are surrounded by vast acreages of winter wheat, corn, and other grain crops, and provide excellent migratory waterfowl habitat. Large numbers of mallards, pintails, teal, and other ducks of the Central Flyway terminate their southward migration in this area. Quail, mourning dove, and wild turkey are also found in the region. Non-migratory birds include the American kestrel, Mississippi kite, common nighthawk, barn and cliff swallows, painted and bunting larks, pine siskin, and American goldfinch. Woodpeckers are prevalent, as are wrens, warblers, sparrows, and meadowlarks.

Common amphibians include tiger salamanders, spadefoot toads, tree frogs, and a few species of frogs. Common reptiles include the red-eared turtle, several lizard species, skunks, and many species of snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the High Plains include: Palo Duro mouse, Arctic peregrine falcon, Bald eagle, Least tern, Interior least tern, Brazos water snake, Concho water snake, Texas horned lizard, Blue sucker.

2.10 Trans-Pecos

The Trans-Pecos region supports a number of species uniquely adapted for survival in arid, desert areas. Small foraging animals include the eastern mole, the Mexican and Crawford shrews, rock squirrel, black-tailed prairie dog, porcupine, California jack rabbit, and Audubon cottontail. Several species of skunks, pocket gophers, mice, rats, and kangaroo rats inhabit the area. The Trans-Pecos region supports numerous bat species. Predatory mammals include black bear, coati, ringtail, weasel, badger, desert and gray foxes, coyote, cougar, and bobcat. Aquatic mammals include the muskrat and beaver. Big game species include white-tailed deer, mule deer, desert bighorn sheep, elk, javelina, and pronghorn.

The Trans-Pecos region supports a number of desert birds such as ladder-backed woodpecker, verdin, rock wren, canyon wren, cactus wren, Pyrrhuloxia, and numerous species of sparrows. Other seasonal residents include flycatchers, virios, warblers, and tanagers. Dove and quail are also common to the region.

Common amphibians include tiger salamanders, spadefoot toads, the Texas toad, and frog species such as the Rio Grande frog. Common reptiles include a few species of turtles, geckos, skunks, and numerous species of snakes.

Threatened and Endangered Species

Threatened and endangered species inhabiting or known to migrate through the Trans-Pecos include: Spotted bat, Mexican long-nosed bat, Mexican wolf, Black bear, Coati, Whooping crane, White-faced ibis, White-tailed hawk, Northern gray hawk, American swallow-tailed kite, Northern aplomado falcon, American peregrine falcon, Arctic peregrine falcon, Bald eagle, Mexican spotted owl, Chihuahuan mud turtle, Big Bend blackhead snake, Texas lyre snake, Reticulated gecko, Texas horned lizard, Mountain short-horned lizard, Mexican stoneroller, Proserpine shiner, Rio Grande chub, Chihuahua shiner, Blue sucker, Leon Springs pupfish, Commanche Springs pupfish, Conchos pupfish, Pecos pupfish, Big Bend gambusia, Pecos gambusia, Rio Grande darter.

3.0 Aquatic Wildlife and Wildlife Habitat

Because of the many species of aquatic animals present in Texas water, a complete species inventory would be a study in and of itself and beyond the scope of this environmental impact statement. However, it is important to list the major species of aquatic animals, especially those of commercial and recreational importance and those listed as threatened or endangered, in order to fully assess potential impacts resulting from the selected alternatives for vegetation management. This section lists the major species of fish by vegetation region, when possible.

3.1 Aquatic Invertebrates

Because of the many species of freshwater macroinvertebrates present throughout the state, no attempt has been made to list these by vegetation region. The following is a brief description of major types (Hendricks, 1994):

Amphipods, also called scuds, are relatively small animals (3 to 12 mm in length) that are related to and resemble isopods. Fresh water amphipods, such as *Hyalella* sp. and *Gammarus* sp., are mostly bottom dwellers in streams and shallow weed beds of lakes. In general these animals are scavengers, and organic detritus is often eaten by these filter feeders.

Chronimids are the larval forms of an aquatic fly called a midge. These larvae are characteristic of the benthic fauna of deeper portions of eutrophic bodies of water.

Cladocerans are minute (typically 1.5 mm in length) and have a distinct head and body that are covered by an unhinged bivalve carapace. These animals form an important portion of the plankton and can be found in various types of water ranging from temporary ponds to stable bodies of water. Cladocerans of the genus *Daphnia* are frequently employed in toxicological studies to represent aquatic invertebrates. These animals are filter feeders and serve as prey for plankton eaters.

Copepods are also quite small. The adults of these forms are cylindrical, partially segmented, and have two long antennae. These animals can be found in a variety of types of water ranging from fresh water to littoral situations. They occur in bottom deposits, on vegetation, and in the plankton.

Decapods are crustaceans of the Order Decapoda including commonly tested animals such as crayfish, grass shrimp, mysid shrimp, penaeid shrimp, and fiddler crabs. These animals are often used in toxicological investigations to represent estuarine invertebrates. The oyster, a bottom dwelling filter feeding mollusk was also occasionally employed in toxicologic investigations.

Rotifers are minute animals that are abundant in natural waters. Some of these animals occur in plankton, others are attached to solid objects in the water, and a large number of them occur in the mud or debris of bodies of water. Representatives of this group can be sac-like or elongate in shape and have a hardened shell-like rigid covering that is frequently ornamented with spines.

Stoneflies are 15 to 50 mm in length, are elongated in shape, and have long antennae. The aquatic immature form of stoneflies (naiads) have gills and lack wings but otherwise resemble adults. Immature stoneflies live beneath the stones of clean, swift streams. Most of the species of this group are herbivorous.

3.2 Fishes

The following sections list the major freshwater and marine species present in Texas by vegetation region.

3.2.1 Pineywoods

The Pineywoods area, with its high precipitation and many perennial streams, supports numerous reservoirs. Major reservoirs of this region include Toledo Bend, Caddo Lake, Sam Rayburn, Lake Livingston, Wright Patman, Lake O' the Pines, and Lake Conroe. The rivers of the Pineywoods generally are slow-moving, meandering, and deep. Major rivers of this region are the Sabine, Neches, and Trinity rivers. The waters of the Pineywoods region support gamefish such as whitebass, blackbass, catfish, crappie, bluegill and sunfish perch. Roughfish in these waters include carp, gar, buffalo, freshwater drum, fathead minnows, and shad. Species endemic to this region are the bluehead shiner and chain pickerel, found in Caddo Lake. The paddlefish has been reintroduced in the Trinity River and Red River basins and eastward.

3.2.2 Gulf Prairies and Marshes

The Gulf Prairies and Marshes contain a myriad of fisheries in the form of rivers, reservoirs, and coastal bays. This area is part of the highly productive estuarine complex which supports marine life in the Gulf of Mexico.

The two major reservoirs in the region are Lake Texana and Coleto Creek Reservoir. The rivers of this region include the lower Sabine, Neches, Trinity, Brazos, Colorado, Guadalupe, San Antonio, Nueces, and Rio Grande. These waters support such gamefish as whitebass, blackbass, catfish, crappie, bluegill, and sunfish perch. Roughfish include gar, carp, buffalo, freshwater drum, fathead minnows, and shad. Saltwater species such as red drum and flounder are found in some of these waters.

The bays and estuaries along the coast contain habitat for such species as red drum, trout, flounder, crabs, shrimp, and oysters.

3.2.3 Post Oak Savannah

Several fisheries exist in the Post Oak Savannah. Major reservoirs include Lake Somerville, Lake Limestone, Lake Fork Reservoir, and Lake Bob Sandlin. Also, several of the major rivers in the state cross this region including the Red, Sulphur, Sabine, Trinity, Navasota, Brazos, Colorado, and Guadalupe rivers. These waters support whitebass, blackbass, bluegill, catfish, crappie, sunfish perch, carp, gar, buffalo, fathead minnows, freshwater drum, and shad. An endemic species to this region is the Blackside Darter of the Red River basin.

3.2.4 Blackland Prairies

The Blackland Prairie supports fish species very similar to those of the Post Oak Savannah. Reservoirs such as Ray Hubbard and Tawakoni support several species of crappie, sunfish, catfish, and bass. Yellow bass is found in most lakes as well.

The regional streams contain numerous species of sunfish, bass, and catfish. The Colorado River contains the Rio Grande cichlids.

3.2.5 Cross Timbers and Prairies

In this region of the state, major reservoirs include Lewisville, Whitney, Ray Roberts, Edwards, Proctor, Possum Kingdom, Arrowhead lakes, and Hubbard Creek Reservoir. This region includes the Trinity, Brazos, Colorado, and Leon rivers. Gamefish of the Cross Timbers and Prairies are whitebass, blackbass, striped bass, bluegill, cutthroat trout, catfish, crappie, and sunfish perch. Roughfish include gar, carp, buffalo, freshwater drum, fathead minnows, and shad.

3.2.6 South Texas Plains

Choke Canyon, Lake Corpus Christi, and the International Falcon Reservoir are three major reservoirs of the South Texas Plains. The Nueces, Rio Grande, Frio, and Atascosa rivers cross this region. These fisheries contain white and blackbass, catfish, crappie, and sunfish perch. Roughfish include gar, carp, buffalo, Rio Grande cichlid, fathead minnows, and shad. The River Goby is an endemic species to this region.

3.2.7 Edwards Plateau

The Edwards Plateau contains many clear streams and reservoirs. The major bodies of water in this region are the International Amistad Reservoir, Canyon, Travis, Lyndon B. Johnson, Buchanan, E.V. Spence, Twin Buttes, and O.H. Ivie lakes. The Edwards Plateau's major rivers include the Rio Grande, Pecos, Devil's, Nueces, Frio, Guadalupe, Pedernales, Llano, San Saba, and Concho. Gamefish of the Plateau include white and blackbass, catfish, crappie, and sunfish perch. Roughfish include gar, carp, freshwater drum, Rio Grande cichlid, and shad. Several species are found only in the Edwards Plateau region, such as the Devil's River minnow, found in Val Verde County creeks, and the Fountain Darter, found in the upper San Marcos and Comal rivers.

3.2.8 Rolling Plains

The major bodies of water in the Rolling Plains region include Kemp, O.C. Fisher, and J.B. Thomas lakes. The major rivers include the Canadian, Red, Brazos, Colorado, and Concho. Black, white, and striped bass, bluegill, cutthroat trout, catfish, crappie, and sunfish perch are all gamefish of the Rolling Plains. Walleye have been stocked in Lake Meredith. Roughfish include gar, carp, freshwater drum, river carpsucker, fathead minnows, and shad.

3.2.9 High Plains

The High Plains region has at least one established fishery for gamefish, Lake Merdith. Streams are largely intermittent, and flow only during periods of heavy rainfall.

3.2.10 Trans - Pecos

Only two reservoirs exist in the vast Trans-Pecos region, Lake Toyah and Red Bluff Lake. The Pecos and the Rio Grande are the only major rivers in the region. Gamefish in these waters include white and black bass, bluegill, catfish, and sunfish perch. Roughfish include carp, gar, river carpsucker, freshwater drum, and shad. Several species are endemic to the Trans-Pecos region, such as the Big Bend Gambusia and the Mexican Stoneroller. The only known self-sustaining population of rainbow trout is located in this region's Guadalupe Mountains.

3.3 Threatened, Endangered and Sensitive Species

Federal policies and procedures for protecting threatened and endangered species of fish, wildlife, and plants have been established by the Endangered Species Act of 1973 and regulations issued pursuant to the act. The purposes of the act are to provide mechanisms for conservation of threatened and endangered species and the habitats upon which they depend, as well as to achieve the goals of international treaties and conventions related to endangered species. Under the Act, the Secretary of the Interior is required to determine which species are threatened or endangered and to issue regulations for the protection of those species.

There are 29 species of freshwater and coastal fish that are listed as either threatened or endangered species by the TPWD.

3.4 Habitat Description and Diversity

Aquatic habitats in Texas are quite diverse, ranging from the marine environment of the Gulf of Mexico to the freshwater environments of the interior basins and plains. Habitat diversity is reflected in the varied fauna and flora found in the lakes, rivers, and estuaries of the state.

Freshwater

There are three major groups of freshwater habitats occurring in Texas. These are lake, river, and wetland habitats. Each group is represented in each of the ten vegetation regions.

Marine

The major marine environment of concern is the Gulf of Mexico. Because the marine waters of the Gulf are primarily estuaries, their natural properties are strongly influenced by the supply of freshwater. Major Texas rivers and some smaller streams flow directly into the Gulf.

The complex network of bays, channels, and waterways in the Gulf support a wide variety of plants and animals in different habitats. The factors that differentiate saltwater habitats include temperature, salinity, wave exposure, current velocity, depth, availability of nutrients, and the texture, stability , and chemistry of the underlying rock or sediment. Based upon these factors, the major marine habitats of the Gulf of Mexico are:

- Open water (pelagic)
- Rocky intertidal and subtidal habitat
- Sandy and mixed coarse sediment habitat
- Muddy intertidal and subtidal habitat
- Eelgrass habitat
- Estuarine wetland habitat

Most of the organisms in the open waters of the Gulf of Mexico are free-floating plankton: either phytoplankton or zooplankton. Phytoplankton is a major original source of food. Zooplankton feeds on phytoplankton and, in turn, becomes prey for larger animals such as fish.

Many species of saltwater fish can be found in the open waters of the Gulf.

Rocky intertidal and subtidal habitats are found where the shoreline of the Gulf is composed of seawalls or outcrops of solid rock. It supports a biological community capable of attaching to hard substrate. Many algae as well as invertebrates such as snails, mussels, and barnacles can be found in these habitats.

Habitats characterized by course sediment, from sand to mixtures of sand, gravel, and cobbles, make up most of the beaches of the Gulf. These course substrates often are subject to energy from waves and currents. Because such a habitat does not offer a firm substrate to which an organism can anchor, many species commonly burrow into the bottom.

This habitat hosts a variety of crustaceans, echinoderms, and molluscs, and both pelagic and bottom fish. The dominant molluscs found in this habitat are intertidal and subtidal.

The muddy intertidal and subtidal habitats tend to be those of the weakest water circulation and most gradual slope. They are found predominantly at the heads of protected bays and mouths of rivers. The intertidal zones of these habitats often grade slowly upland into saltwater marshes.

Deep water soft-bottom habitats are widespread throughout the Gulf at the bottoms of basins or in inlets with sluggish circulation. Characteristic assemblages of clams, worms, starfish, sea cucumbers, sea urchins, crabs, hydrocorals, and brachiopods inhabit various depths in this domain. Some popular sport fish are found on soft-bottom habitats including flounders and sole.

Shallow subtidal soft-bottom communities are often characterized by the presence of eelgrass, a dominant plant species in the Gulf. The sediment in these areas is characterized by a high organic content and these areas are highly productive. Eelgrass beds perform an important role in supporting the larvae and juvenile stages of many types of commercial and sport fish.

Estuarine wetlands include vegetated salt marshes, eelgrass beds, and unvegetated mudflats. Unvegetated wetlands support secondary production activities and are an important habitat for fish, shellfish, marsh and waterbirds, and shorebirds.

4.0 Environmental Consequences of Treatments

Roads affect wildlife populations through their effects on habitats and animal movements. Depending on the type of road and the characteristics of the surrounding habitat and wildlife community, roads can act as either corridors or barriers to animal movement, enhancing or isolating populations. In forested landscapes, for example, species that favor open habitats utilize roadways as travel and hunting routes. Other animals typically (though not always) avoid well-traveled roads. Smaller vertebrates may choose not to cross roads at all, but many rely on edges along ROW.

Highway mortality of animals is a serious problem in some areas, particularly for animals with large home ranges that encompass well-traveled roads. In Florida, for example, roadkills are the major known cause of death for all remaining large mammals except white-tailed deer (WSDOT, 1993).Although roadkill statistics are not available in Texas, there is some evidence that roads can significantly affect animal populations in some circumstances.

Studies by Pojar (1971) and others, however, suggest that roadside management practices have little influence on roadkills. Large numbers of roadkills occur where highways intersect preferred habitats in adjacent lands. Maintenance practices do not greatly alter traditional movements, patterns, or migratory corridors (TxDOT, 1993).

Roadside vegetation management can influence wildlife populations indirectly through its effect on habitat. Effects may be either beneficial or harmful depending on the location, site characteristics, species affected, and the type, timing, intensity, and frequency of treatment. In most cases the effect depends on the habitat changes caused by the treatment rather than the particular method utilized. The extent that vegetation management supports habitat use and normal movements of desirable native species of wildlife can be a beneficial management tool. Where vegetation management reduces the structural and compositional diversity of native vegetation, or promotes the dispersal of opportunistic, invasive organisms (either native or non-native), it is harmful. It is imperative that wildlife and habitat responses to pest management be evaluated and monitored on a situation-specific, individual treatment basis.

Eliminating roadside vegetation treatments could result in other improved or deteriorated wildlife habitat on some sites, depending on the vegetation removed. Lack of periodic disturbance to soils and vegetation would allow some native plant communities to remain or become established, favoring animals associated with these habits. Other native plant communities, however, would be compromised by aggressive invasion by exotic pest plants. Wildlife associated with these native plants would not be favored. This could be particularly beneficial to wildlife populations in portions of Texas where natural habitats are increasingly impacted by grazing, agriculture, and land development.

Unmanaged roadside habitats could also attract large herbivores, predators, and scavengers, increasing potential for roadkills. Theoretically, some of the larger threatened or endangered species could be affected. However, since these animals range over hundreds of square miles, primarily in roadless areas, the risk to such species would be minimal.

The potential impacts of roadside vegetation control methods on aquatic habitats and resources are directly related to any impacts upon water quality. Potential adverse effects include survival or reproduction of aquatic organisms resulting from habitat degradation or toxic effects.

The quality of aquatic habitats depends on hydrology, water temperature, total dissolved oxygen, food supply, protective cover, sediment and nutrient loads, availability of spawning and nursery areas, and the presence of toxic materials. Aquatic habitat degradation resulting from increased sediment and nutrient loading is the most likely adverse effect of vegetation control along TxDOT ROW. Effects could include turbidity-induced gill abrasion and covering of spawning habitat.

4.1 Chemical Techniques

Impacts of chemical vegetation control may be direct, toxicological effects, or indirect effects from habitat alterations. This section addresses the effects of herbicide use on wildlife habitats. Toxicological impacts to terrestrial and aquatic wildlife are discussed in Appendix B, Chapter 3.

Habitat changes resulting from pesticide applications are beneficial to some animals and harmful to others. As the habitat changes, the wildlife community associated with it will change. Chemical treatment of noxious weeds is beneficial to most, but not all, wildlife species, since some of these plants are highly utilized as food. Seeds of thistles and other annual weeds, for example, are eaten by many species of finches and other birds.

As with other treatments, the response of wildlife to chemical control depends on the chemical used, how it is applied, its effect on habitat, and the availability of cover and forage in treated and adjacent untreated areas. Spot applications to individual plants or use of selective herbicides, which target only specific undesirable plants, are not expected to have significant impacts on wildlife population. Suppression of vegetation in Zone 1a is used to maintain structural integrity of the road and driver safety, and should not harm wildlife habitat.

Chemical applications that could eliminate habitat or affect food sources should be avoided near sites occupied by threatened and endangered species.

Chemical methods of vegetation management along TxDOT ROWs can potentially have both direct and indirect effects upon aquatic habitats and resources. The use of chemical methods can have substantial effects on water quality because of accidental direct application, spray drift, and transport of herbicides to surface waters due to runoff.

Herbicide residues can be mobilized by surface transport or overland flow, entering surface waters in solution or adsorbed on particulate matter. An assessment of leaching and surface loss risks for each chemical is presented in Appendix B, Chapter 4.

Herbicides and insecticides entering aquatic environments may directly impact plants or prey species, reducing their numbers, and thus indirectly affecting predator species.

Insecticide applications may affect wildlife species either directly or indirectly. The use of chemicals selective for certain pest insects will reduce impacts on other non-target insects. Applications of granule formulations may be ingested by birds, with injury or mortality resulting. Other wildlife species may be indirectly affected by a decrease in the number of insects for food, although this impact is unlikely. Appendix A, Chapter 3 contains wildlife toxicity profiles for the chemicals proposed for use by TxDOT.

4.2 Cultural Techniques

Cultural control of roadside vegetation, through seeding of desirable competitive native species, has the potential to improve wildlife habitat along roadsides. Animals would benefit, for example, by planting of species utilized as food. Where plantings result in the establishment of native plant communities and the reduction of noxious weeds, wildlife will also benefit. In roadside areas where deer populations are likely to cross, it may be advantageous to seed species that are relatively unpalatable to these animals.

Cultural techniques generally have a low potential for adversely affecting water quality.

4.3 Biological Techniques

Biological control is a long-term process with limited potential for roadside habitat improvement. Present biological research studies in Texas are limited to a few species of noxious weeds, such as musk thistle and goathead. Some of these plants poison livestock or displace desirable forage for both wildlife and livestock. To the extent that biological control allows more palatable native vegetation to become established along roadsides, wildlife habitats will improve. Whether this will result in greater wildlife use of the roadside habitats depends on plant community characteristics, adjacent habitat types, and affected wildlife species.

Biological techniques have the potential to promote soil erosion by eliminating groundcover when applied to large stands of a pest targeted species. The resulting erosion can degrade water quality and aquatic habitats. This effect is not likely on ROWs as pest plant stands are generally too small to allow feasible use of biological agents.

4.4 Mechanical Techniques

Hawks, other predators, and scavengers may be attracted to highway corridors, where they hunt small mammals along median strips or feed on animals killed by motor vehicles. In situations where mechanical control is used to reduce tree cover along highways, the subsequent growth of shrubs and herbs could improve habitat for small mammals and birds. Greater prey abundance may improve foraging conditions for predators and scavengers.

Mowing of roadside vegetation reduces nesting and hiding cover and food availability for small birds and mammals. Use of mechanical equipment can result in soil compaction and accelerated erosion, damaging the habitat of burrowing animals. The widely varied effects of mechanical treatments on wildlife dictate the need for situation-specific analysis. Properly-timed mowing should enhance habitat during critical periods for wildlife. TxDOT and TPWD have a memorandum of understanding restricting roadside mowing to late fall and winter.

Manual control techniques are generally reserved for sites where other methods of vegetation control are impractical. Wildlife habitat is affected by removal or alteration of specific plants that may be utilized for food and cover. Because manual control methods are labor-intensive, treatments are usually very localized. Resulting wildlife impacts are therefore usually minor.

Mechanical methods such as mowing generally have a low potential to impact aquatic habitats through soil erosion because they result in substantial retention of plant cover. However, grading and discing create a high potential for soil erosion by exposing soil which can then be carried to aquatic habitats during storm events. The resulting sedimentation can degrade aquatic habitats.

4.5 Unavoidable Adverse Impacts

Chemical treatment of roadside vegetation zones 1b and 2 adversely affects the habitats of some wildlife species as vegetation types are enhanced or disadvantaged. Using selective herbicides or spot applications of herbicides reduces adverse impacts on wildlife habitat.

Mowing and other mechanical treatments in roadside Zones 1b and 2 can result in soil compaction, disturbance, and increased erosion. These impacts can be mitigated, but not totally eliminated, by operating during the dry seasons.

Properly-timed mowing can enhance wildlife habitat value. Situation-specific review of environmental factors when considering mechanical treatments reduces adverse effects on animals and their habitats.

Cultural and biological vegetation treatments on roadsides produce no significant unavoidable adverse impacts on wildlife habitat.

Any of the techniques employed for the management of roadside vegetation are likely to impact the environment to some degree. As discussed above, the most likely impact is that from soil erosion due to elimination of groundcover. In the case of herbicide application, some of the herbicide will occasionally be deposited directly in aquatic habitat as a result of spray drift or surface runoff. The degree of impact is dependent upon the concentration that non-target organisms are exposed to and the duration of that exposure.

Table A8-1. Common Wildlife Species in Texas

Common Name	Scientific Name
Mammals	
Armadillo	*Dasypus novemcinctus*
Axis deer	*Axis axis*
Badger	*Taxidea taxus*
Banner-tailed kangaroo rat	*Dipodomys spectabilis*
Bats	*Chiroptera spp.*
Beaver	*Castor canadensis*
Black bear	*Ursus americanus*
Blackbuck antelope	*Antilope cervicapra*
Bobcat	*Lynx rufus*
Botta gopher	*Thomomys bottae*
California jackrabbit	*Lepus californicus*
Coati	*Nasua narica*
Cougar	*Felis concolor*
Coyote	*Canis latrans*
Desert bighorn sheep	*Ovis canadensis*
Elk	*Cervus canadensis*
Eastern cottontail	*Sylvilagus floridanus*
Eastern flying squirrel	*Glaucomys volans*
Eastern mole	*Scalopus aquaticus*
Fallow deer	*Dama dama*
Foxes	*Urocyon spp.*
Fox squirrel	*Sciurus niger*
Gray fox	*Urocyon cinereoargenteus*
Gray squirrel	*Sciurus carolinensis*
Javelina	*Pecari angulatus*
Loring kangaroo rat	*Dipodomys spp.*
Mexican ground squirrel	*Citellus mexicanus*
Mink	*Mustela vision*
Mouse	*Mus musculus*
Mule deer	*Odecoileus hemionus*
Muskrat	*Ondatra zibethica*
Nutria	*Myocastor coypus*
Oppossum	*Didelphis marsupialis*
Ord kangaroo rat	*Dipodomys ordi*
Pocket gopher	*Geomyidae spp.*
Prairie dog	*Cynomys spp.*
Pronghorn antelope	*Antilocapra americana*

Table A8-1. Common Wildlife Species in Texas (continued)

Raccoon	*Procyon lotor*
Rat	*Rattu rattus*
Red wolf	*Canis niger*
Ringtail	*Bassariscus astutus*
River otter	*Lutra canadensis*
Shrew	*Sorex spp.*
Sika deer	*Cervis nippon*
Skunks	*Mephitis spp.*
South Texas pocket gopher	*Geomys personatus*
Spotted ground squirrel	*Citellus spilosoma*
Swamp rabbit	*Sylvilagus aquaticus*
Thirteen-lined ground squirrel	*Citellus tridecemlineatus*
Weasel	*Mustela spp.*
White-tailed deer	*Odoecoileus virginianus*

Birds

American goldfinch	*Spinus tristis*
American kestrel	*Falco sparverius*
Belted kingfisher	*Megaceryle alcyon*
Bewick's wren	*Thryomanes bewickii*
Black vulture	*Coragyps atratus*
Black-throated sparrow	*Amphispiza bilineata*
Blue jay	*Cyanocitta cristata*
Boat-tailed grackle	*Cassidix mexicanus*
Brown thrasher	*Toxostoma rufum*
Brown towhee	*Pipilo fuscus*
Bushtit	*Psaltriparus minimus*
Cactus wren	*Campylorhynchhus brunneicapill*
Canyon wren	*Catherpes mexicnus*
Cardinal	*Richmondena cardinalis*
Cedar waxwing	*Bombycilla cedrorum*
Chickadee	*Parus spp.*
Cliff swallow	*Petrochelidon pyrrhonota*
Coot	*Fulica americana*
Cuckoo	*Cuculidae spp.*
Curved-billed thrasher	*Toxostoma curvirotsre*
Eastern bluebird	*Sialia sialis*
Eastern phoebe	*Sayornis phoebe*
Eastern screech owl	*Otus asio*

Table A8-1. Common Wildlife Species in Texas (continued)

Egret	*Casmerodius albus*
Golden eagle	*Aquila chrysaetos*
Golden-fronted woodpecker	*Centurus aurifrons*
Goose	*Anserinae spp.*
Gull	*Larinae spp.*
Heron	*Ardea spp.*
Ibis	*Threskiornithidae spp.*
Inca dove	*Scardafella inca*
Killdeer	*Charadrius vociferus*
Ladder-backed woodpecker	*Dendrocopos scalaris*
Least grebe	*Podiceps dominicus*
Loggerhead shrike	*Lanius excubitor*
Long-billed thrasher	*Toxostoma longirostre*
Mallard	*Anas platyrhynchos*
Meadowlark	*Sturnella magna*
Mississippi kite	*Ictinia mississippiensis*
Mockingbird	*Mimus polyglottus*
Mourning dove	*Zenaidura macroura*
Olive sparrow	*Arremonops rufivirgata*
Osprey	*Pandion haliaetus*
Owl	*Strigidae spp.*
Painted bunting	*Passerina ciris*
Pine siskin	*Spinus pinus*
Pintail	*Anas acuta*
Purple martin	*Progne subis*
Pyrrhuloxia	*Pyrrhuloxia sinuata*
Quail	*Phasianidae spp.*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Roadrunner	*Geococcyx californianus*
Robin	*Turdus migratorius*
Rock dove	*Columba livia*
Rock wren	*Salpincte obsoletus*
Rufous-crowned sparrow	*Aimophila ruficeps*
Sandpiper	*Scolopacidae spp.*
Scissor-tailed flycatcher	*Muscivora forficata*
Scrub jay	*Aphelocoma coerulescens*
Spoonbill	*Ajaia ajaja*
Swainson's hawk	*Buteo swainsoni*
Swallow	*Hirundinidae spp.*

Table A8-1. Common Wildlife Species in Texas (continued)

Tanager	*Piranga spp.*
Tern	*Sterninae spp.*
Titmouse	*Parus spp.*
Tufted titmouse	*Parus atricristatus*
Turkey vulture	*Cathartes aura*
Warbler	*Parulidae spp.*
White-fronted Dove	*Leptotila verreauxi*
White-necked raven	*Corvus cyrptoleucus*
Wild turkey	*Meleagris gallopavo*
Wood duck	*Anas sponsa*
Woodpecker	*Picidae spp.*
Wren	*Troglodytidae spp.*
Verdin	*Auriparus flaviceps*
Virio	*Vireonidae spp.*
Reptiles and Amphibians	
Alligator	*Alligator mississippiensis*
Banded gecko	*Coleonyx variegatus*
Box turtle	*Terrapene ornata*
Greater earless lizard	*Cophpsaurus texanus*
Red-eared turtle	*Chrysemys scripta*
Salamander	*Amystomatids, Dicamptodontids* spp.
Sea turtles	*Cheloniids, Dermochelyids spp.*
Skink	*Eumeces spp.*
Snakes	*Boidae, Colubridae, Viperidae spp.*
Spadefoot toad	*Scaphiopus spp.*
Texas spiney lizard	*Phrynosoma cornutum*
Tiger salamander	*Ambystoma tigrinum*
Toad	*Bufo spp.*
Treefrog	*Hyla spp.*
Water turtle	*Emydids, Chelyrids spp.*
Fish	
Big Bend gambusia	*Gambusia gaigei*
Blackbass	*Synagrops bellus*
Blackside darter	*Percina maculata*
Bluegill	*Lepomis macrochirus*
Bluehead shiner	*Elops saurus*

Table A8-1. Common Wildlife Species in Texas (continued)

Carp	*Cyprinus carpio*
Catfish	*Ictalurus punctatus*
Crappie	*Pomoxis annularis*
Cutthroat trout	*Salmo clarki* or *Oncrorhynchus clarki*
Devil's River minnow	*Cypriodon or*
Fathead minnow	*Pimephales promelas*
Flounder	*Paralichthys spp.*
Fountain darter	*Etheastoma fonticola*
Gar	*Lepisosteus spatula*
Mexican stoneroller	*Campostoma ornatum*
Paddlefish	*Polyodon spathula*
Rainbow trout	*Salmo gairdneri* or *Oncorhynchus mykiss*
Red drum	*Sciaenops ocellata*
Rio Grande cichlids	*Cichlid spp.*
River goby	*Awaous rajasica*
Shad	*Dorosma spp.*
Striped bass	*Morone saxatilis*
Trout	*Salmo spp.*
Walleye	*Salmo spp.*
Whitebass	*Morone americana*

Table A8-2. Threatened and Endangered Wildlife Species in Texas

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** MAMMALS ***			
Bats				
Euderma maculatum	Spotted bat	T	C2	Trans-Pecos region
Lasiurus ega	Southern yellow bat	T		Extreme south Texas
Leptonycteris nivalis	Mexican long-nosed bat	E	LE	Brewster and Presidio Counties
Plecotus rafinesquii	Eastern big-eared bat	T	C2	Eastern Texas
Rodents				
Dipodomys elator	Texas kangaroo rat	T	C2	Extreme north-central Texas
Oryzomys couesi	Coue's rice rat	T	C2	Lower Rio Grande Valley
Peromyscus truei comanche	Palo Duro mouse	T	C2	Armstrong, Briscoe and Randall Cos.
Marine Mammals				
Balaenoptera musculus	Blue whale	E	LE	Gulf Coast marine waters
Balaenoptera physalus	Finback whale	E	LE	Gulf Coast marine waters
Eubalaena glacialis	Black right whale	E	LE	Gulf Coast marine waters
Feresa attenuata	Pygmy killer whale	T		Gulf Coast marine waters
Globicephala macrorhyncyhus	Short-finned pilot whale	T		Gulf Coast marine waters
Kogia breviceps	Pygmy sperm whale	T		Gulf Coast marine waters
Kogia simus	Dwarf sperm whale	T		Gulf Coast marine waters
Mesoplodon europaeus	Gervais' beaked whale	T		Gulf Coast marine waters
Orcinus orca	Killer whale	T		Gulf Coast marine waters
Physeter catodon	Sperm whale	E	LE	Gulf Coast marine waters
Pseudorca crassidens	False killer whale	T		Gulf Coast marine waters
Stenella plagiodon	Atlantic spotted dolphin	T		Gulf Coast marine waters
Steno bredanensis	Rough-toothed dolphin	T		Gulf Coast marine waters
Trichechus manatus	Manatee	E	LE	Coastal marshes and marine waters
Ziphius cavirostris	Goose-beaked whale	T		Gulf Coast marine waters
Carnivores				
Canis lupus	Gray wolf	E	LE	Extirpated, statewide
Canis lupus baileyi	Mexican wolf	E	LE	Occasional migrant, Big Bend area
Canis rufus	Red wolf	E	LE	Extirpated, possibly deep SE Texas
Felis pardalis	Ocelot	E	LE	South Texas
Felis wiedii	Margay	E		Extirpated, south Texas
Felis yagouaroundi	Jaguarundi	E	LE	Extreme South Texas
Mustela nigripes	Black-footed ferret	E	LE	Extirpated from Texas
Nasua nasua	Coati	E		South, southwest & Trans-Pecos
Panthera onca	Jaguar	E		Extirpated from Texas
Ursus americanus	Black bear	E	LT	Occasional south & west Texas migrants
Ursus americanus luteolus	Louisiana black bear	E	LT	Extirpated, deep east Texas

Table A8-2. Threatened and Endangered Wildlife Species in Texas (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** BIRDS ***			
	Waterbirds			
Egretta rufescens	Reddish egret	T	C2	Coastal, occasionally far inland
Grus americana	Whooping crane	E	LE	Aransas & Matagorda Cos., migrant north
Mycteria americana	Wood stork	T		Coastal, eastern, central, Rio Grande
Pelecanus occidentalis	Brown pelican	E	LE	Coastal counties
Plegadis chihi	White-faced ibis	T	C2	Coastal, central and western Texas
	Raptors			
Buteo albicaudatus	White-tailed hawk	T		Coastal prairies, occasional westward
Buteo albonotatus	Zone-tailed hawk	T		Trans Pecos, Edwards Plateau, Rio Grande
Buteo nitidus maximus	Northern gray hawk	T	C2	Lower Rio Grande Valley to Trans Pecos
Buteogallus anthracinus	Common black-hawk	T		Davis Mts to Rio Grande Valley
Elanoides forficatus	American swallow-tailed kite	T	3C	Migrant statewide except Panhandle
Falco femoralis septentrionalis	Northern aplomado falcon		LE	Migrant west, southern, & lower coastal
Falco peregrinus anatum	American peregrine falcon	E	LE	Chisos & Guadalupe Mountains
Falco peregrinus tundrius	Arctic peregrine falcon	T	LT	Migrant across state
Glaucidium brasilianum	Ferruginous pygmy-owl	T		Rio Grande Valley, N. to Kennedy Co.
Glaucidium brasilianum cactorum	Cactus ferruginous pygmy-owl	T	C1	Rio Grange Valley
Haliaeetus leucocephalus	Bald eagle	E	LE	Migrant & resident throughout state
Strix occidentalis lucida	Mexican spotted owl		LE	Extreme West Texas; Wooded Canyons
	Shorebirds			
Charadrius melodus	Piping plover	T	LT	Migrant in eastern half of state
Numenius borealis	Eskimo curlew	E	LE	Galveston Co, possibly extinct
Sterna antillarum	Least tern		LE	Gulf Coast and extreme NE Texas
Sterna antillarum athalassos	Interior least tern	E	LE	Panhandle & eastern 2/3 state
Sterna dougallii	Roseate tern		LT	Cameron, Calhoun, Galveston & Nueces
Sterna fuscata	Sooty tern	T		Coastal areas, occasional to cental
	Upland Birds			
Tympanuchus cupido attwateri	Attwater's prairie-chicken	E	LE	Coastal, Galveston to Refugio Cos.
	Woodpeckers			
Campephilus principalis	Ivory-billed woodpecker	E	LE	Extirpated, eastern third of state
Picoides borealis	Red-cockaded woodpecker	E	LE	East Texas Piney-woods

Table A8-2. Threatened and Endangered Wildlife Species in Texas (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** BIRDS (cont) ***			
	Songbirds			
Aimophila aestivalis	Bachman's sparrow	T	C2	East Texas Piney-woods
Aimophila botterii texana	Texas botteri's sparrow	T	C2	Rio Grande Valley & lower coastal
Campstostoma imberbe	Northern beardless tyrannulet	T		Rio Grande Valley & lower coastal
Dendroica chrysoparia	Golden-cheeked warbler	E	LE	Ashe Juniper areas of central Texas
Pachyramphus aglaiae	Rose-throated becard	T		Rio Grande Valley below Falcon Dam
Parula pitiayumi nigrilora	Tropical parula	T	C2	Rio Grande Valley & lower coastal
Vermivora bachmanii	Bachman's warbler		LE	Extirpated, possibly Big Thcket area
Vireo atricapillus	Black-capped vireo	E	LE	Edwards Plateau, west and north
	*** REPTILES ***			
	Turtles			
Caretta caretta	Loggerhead sea turtle	E	LT	Gulf coast marine waters
Chelonia mydas	Green turtle	T	LT	Gulf coast marine waters
Dermochelys coriacea	Leatherback sea turtle	E	LE	Gulf coast marine waters
Eretmochelys imbracata imbricata	Atlantic Hawksbill Sea Turtle	E	LE	Gulf coast marine waters
Eretmochelys imbricata	Hawksbill Sea Turtle		LE	Gulf coast marine waters
Gopherus berlandieri	Texas Tortoise	T		Southern Texas
Kinosternon hirtipes murrayi	Chihuahuan mud turtle	E	C2	Presido County
Lepidochelys kempii	Kemp's ridley sea turtle	E	LE	Gulf coast marine waters
Macroclemys temminckii	Alligator snapping turtle	T	C2	Eastern Texas
	Snakes			
Cemophora coccinea copei	Northern scarlet snake	T		East Texas
Cemophora coccinea lineri	Texas scarlet snake	T		South Texas,coastal counties
Coniophanes imperialis	Black-striped snake	T		Cameron, Hidalgo and Willacy Cos.
Crotalus horridus	Timber rattlesnake	T		Eastern third of Texas
Drymarchon corais	Indigo snake	T		South Texas
Drymobius margaritiferus	Speckled racer	E		Cameron County
Leptodeira s. septentrionalis	Northern cat-eyed snake	E		Valley of south Texas
Nerodia harteri harteri	Brazos water snake	T	C2	Upper Brazos River
Nerodia harteri paucimaculata	Concho water snake	E	LT	Upper Colorado River
Opheodrys vernalis	Smooth green snake	E		Extreme southeast Texas
Pituophis melanoleucus ruthveni	Louisiana pine snake	E	C2	Far East Texas
Tantilla rubra	Big Bend blackhead snake	T		Southern Trans Pecos
Trimorphodon biscutatus vilkinsoni	Texas lyre snake	T		El Paso, Hudspeth, Presido, Brewster

Table A8-2. Threatened and Endangered Wildlife Species in Texas (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	* * * REPTILES (cont) * * *			
	Lizards			
Coleonyx reticulatus	Reticulated gecko	T	3C	Brewster and Presidio Cos.
Crotaphytus reticulatus	Reticulate collared lizard	T	C2	South Texas, scattered localities
Phrynosoma cornutum	Texas horned lizard	T	C2	Statewide
Phrynosoma douglassii hernandesi	Mountain short-horned lizard	T		Extreme west Texas
	* * * AMPHIBIANS * * *			
	Salamanders			
Eurycea nana	San Marcos salamander	T	LT	Upper San Marcos River
Eurycea tridentifera	Comal blind salamander	T	C2	Comal and Bexar Counties
Notophthalmus meridionalis	Black-spotted newt	E	C2	Southern Texas coastal counties
Siren intermedia texana	Rio Grande lesser siren	E	C2	Southern Texas
Typhlomolge rathbuni	Texas blind salamander	E	LE	Hays County
Typhlomolge robusta	Blanco blind salamander	E	C2	Hays County
	Frogs			
Bufo houstonensis	Houston toad	E	LE	Bastrop, Burleson, Colorado, Harris Cos.
Hypopachus variolosus	Sheep frog	T		Southern Texas
Leptodactylus fragilis	White-lipped frog	E		Cameron, Hidalgo and Starr Cos.
Rhinophrynus dorsalis	Mexican burrowing toad	T		Starr and Zapata Counties
Smilisca baudinii	Mexican treefrog	T		Cameron and Hidalgo Counties
	* * * FISHES * * *			
	Large River Fish			
Polyodon spathula	Paddlefish	E	C2	Reintroduced, Trinity Basin eastward
Scaphirhynchus platorynchus	Shovelnose sturgeon	E		Red River below Dennison Dam
	Minnows			
Campostoma ornatum	Mexican stoneroller	T	C2	Rio Grande in Brewester & Presido Cos.
Cyprinella proserpina	Proserpine shiner	T	C2	Devil's & lower Pecos R., nearby creeks
Dionda diaboli	Devil's River minnow	T	C1	Val Verde County creeks
Gila pandora	Rio Grande chub	T		Davis Mountains
Notropis chihuahua	Chihuahua shiner	T	C2	Big Bend region
Notropis hubbsi	Bluehead shiner	T		Caddo Lake
Notropis orca	Phantom shiner	E	3A	Extinct, Rio Grande mouth to El Paso
Notropis simus	Bluntnose shiner	E		Extirpated, upper Rio Grande & Pecos
	Suckers			
Cycleptus elongatus	Blue sucker	T	C2	Large rivers statewide

Table A8-2 Threatened and Endangered Wildlife Species in Texas (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	* * * **FISHES (cont)** * * *			
Erimyzon oblongatus	Creek chubsucker	T		Red River south to San Jacinto drainage
	Catfish			
Satan eurystomus	Widemouth blindcat	T	C2	San Antonio pool of the Edwards Aquifer
Trogloglanis pattersoni	Toothless blindcat	T	C2	San Antonio pool of the Edwards Aquifer
	Killifishes			
Cyprinodon bovinus	Leon Springs pupfish	E	LE	Leon Creek, Pecos County
Cyprinodon elegans	Comanche Springs pupfish	E	LE	Jeff Davis and Reeves Counties
Cyprinodon eximius	Conchos pupfish	T	C2	Devil's R & Rio Grande to Conchos R.
Cyprinodon pecosensis	Pecos pupfish	T	C1	Pecos River tributaries
	Livebearers			
Gambusia gaigei	Big Bend gambusia	E	LE	Big Bend National Park
Gambusia georgei	San Marcos gambusia	E	LE	Extinct, upper San Marcos River
Gambusia heterochir	Clear Creek gambusia	E	LE	Menard Co., headwaters Clear Creek
Gambusia nobilis	Pecos gambusia	E	LE	Jeff Davis, Pecos and Reeves Cos.
Gambusia senilis	Blotched gambusia	E	C2	Devil's River, believed extirpated
	Perches			
Etheostoma fonticola	Fountain darter	E	LE	Upper San Marcos and Comal Rivers
Etheostoma grahami	Rio Grande darter	T	C2	Rio Grande & Pecos R. above Devil's R.
Percina maculata	Blackside darter	E		Red River Basin, northeastern Texas
	Coastal Fishes			
Awaous tajasica	River goby	T		Rio Grande, Hidalgo and Willacy Cos.
Gobionellus atripinnis	Blackfin goby	E		South Texas, lower Rio Grande, estuarine
Microphis brachyurus	Opposum pipefish	T		Rio Grande in Cameron County

Table A8-2. Threatened and Endangered Wildlife Species in Texas (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** INVERTEBRATES ***			
	Spiders			
Tartarocreagris texana	Tooth Cave pseudoscorpion		LE	
Neoleptoneta myopica	Tooth Cave spider		LE	
Texella reddelli	Bee Creek Cave harvestman		LE	
Texella reyesi	Bone Cave Harvestman		LE	
	Insects			
Rhadine persephone	Tooth Cave ground beetle		LE	
Texamaurops reddelli	Kretschmarr Cave mold beetle		LE	
Batrisodes texanus	Coffin Cave mold beetle		LE	

KEY STATE STATUS: E = Endangered
T = Threatened

FEDERAL STATUS: LE = Listed Endangered,
LT = Listed Threatened
PT = Proposed Threatened
C1 = Candidate Species (category 1 - awaiting listing)
C2 = Candidate Species (category 2 - awaiting more information)
3A = Removed from list due to extinction
3C = Removed from list due to abundance

Appendix A - Chapter 9

1.0 Introduction

One of the primary goals which vegetation management of highways strives to achieve is the visual integration of the highway into adjacent land uses, and not the creation of a separate entity within the overall landscape. At the same time, safety is enhanced by the careful delineation of the travel way.

The visual quality of a highway is measured in terms of the extent of visual elements offered along the highway. Visual elements include landforms, vegetation, water, color, and adjacent scenery. Visual elements can be measured by the sum of four basic criteria: vividness, intactness, unity, and compatibility.

Vividness: The visual impression received from contrasting landscape elements as they combine to form a striking and distinctive visual pattern.

Intactness: The integrity of visual order in the natural and man-built landscape, and the extent to which the landscape is free from visual encroachment.

Unity: The degree to which the visual resources of the landscape join together to form a coherent, harmonious visual pattern. Unity refers to the compositional harmony or inter-compatibility between landscape elements.

Compatibility: The degree to which development with specific visual characteristics is unified within the landscape setting.

Aesthetics and Visual Resource Management for Highways (Jones and Jones, date unknown) is often used as a guide for assessing the visual quality and impacts of proposed highways. The document addresses techniques to make evaluations and judgments on a situation-specific basis. The key elements, vividness, intactness, unity, and compatibility, can be utilized in conceptual terms. In assessing the visual quality and impacts of vegetation management techniques, many generalizations must be made which may overlook unique visual situations. Those unique situations should be examined on a situation-specific, case-by-case basis.

1.1 Unique Situations

1.1.1 Scenic Highways, Parks, and Points of Interest

Designated trails, scenic highways, national parks, recreation areas, and other scenic points of interest may be highly sensitive to visual change. Most scenic areas located in natural environments would be focused around the natural features. Roadside vegetation management is usually perceived as an intrusion into the landscape.

1.1.2 Speed of Travel

The impression of the visual quality may change as speed of travel changes. At slower speeds, details would be more noticeable. For example, at high speeds a viewer may notice a mass of shrubs and associate them with a large planting bed, whereas at slower speeds, a viewer may identify those shrubs as noxious plants encroaching on the otherwise aesthetically pleasing landscape.

1.1.3 Traffic Volume

High volumes of traffic and urban congestion may detract attention from visual resources. In high volume areas, motorists must pay close attention to the road and to other vehicles. Roadside vegetation becomes excess information to someone attempting to navigate today's urban traffic. On the other hand, mass transit, as well as cars, and van pools, expose large numbers of viewers to the highway environment each day. The users of the transit system spend more time viewing the roadside vegetation and may be more aware of changes especially at slow, rush-hour speeds.

1.1.4 Views

Vegetation management significantly impacts views. Desirable views can be created by trimming taller vegetation. Vegetation can be used to frame, enhance, and draw attention to specific views. In many areas, the roadside vegetation is the primary visual element along the highway where views may be limited by tall vegetation and high embankments on either side of the highway. The landscape treatment should provide visual relief between the roadway and adjacent land uses. Roadside vegetation may also visually screen the road from adjacent properties and vice versa. Roadside vegetation could improve the visual quality of scenic and other highways by screening unsightly views such as power lines, junk yards, etc.

1.1.5 Edge Conditions

The edge condition of the roadside could affect visual quality of the highway in a number of ways. A strong contrast between trees, shrubs, and grasses could create visual interest along the length of a roadway corridor, as well as become a unifying element, particularly in urban areas.

2.0 Visual Consequences of Maintenance Techniques

Visual impacts of vegetation management may vary with the type of technique, frequency and intensity of treatment, and the time of year in which maintenance activities would be performed. These techniques also could vary with the different vegetation regions in Texas. Where the growing season is longer, additional management activities may be required to maintain roadside vegetation. Where natural areas occur along the highway, maintenance management activities that preserve, protect and enhance the natural qualities should be utilized. The goal of vegetation management along highways is to ensure the safety of the traveling public, protect the structural integrity of the highway, provide a highway that is visually pleasing, and to protect and enhance the natural environment.

2.1 Chemical Techniques

Chemically treating undesirable vegetation could have almost immediate results. TxDOT's conservative applications would tend to have minor negative impacts, however. Chemicals should not be applied when windy conditions would carry the spray away from the target area. Spray distribution may also be affected by air turbulence from vehicular traffic. The use of adjuvants mixed into the solution could minimize the amount of drift. The roots of vegetation found in cracks and joints of paved areas or rip-rap may cause further cracking and reduce the visual quality and structural integrity of the highway pavement or structure.

Careful attention to time of application could greatly reduce visual impacts. Herbicides applied in late summer or early fall would have less impact than if applied in spring. "Brown-out" from herbicides accompanies the natural leaf drop of deciduous plants.

2.1.1 Selective Treatments

Selective treatments would affect only specific target plants. The affected vegetation will turn brown and die, leaving the desirable plants to grow and take over the affected area, which in turn improves the overall visual quality of the affected area. The visual impacts of brown-outs could increase if a greater number of targeted plants were sprayed. Visual impacts from spot applications should be negligible for users of the roadway. Foliar spray treatments usually would be applied near the end of rapid growth, so the period of brownout should be transitory.

2.1.2 Nonselective Treatments

Nonselective treatments would affect all vegetation, often to varying degrees. The treated plants may turn brown and eventually die, leaving dead foliage or bare branches. The affected area could be subject to soil erosion from a rain if not promptly revegetated or covered with mulch. Visual impacts could increase as the size of the treated area increases. TxDOT does not specify nonselective treatments.

2.1.3 Residual Treatments

Residual treatments depend, at least in part, on root uptake of materials applied on or in the soil. Following application, the chemical is active in the soil for an indefinite time. The half-life, or the time it takes for the chemical to degrade to one-half of its applied strength, depends on soil temperature, soil moisture, the resident microbial population, soil texture, the various physical/chemical properties of the herbicide, and the plants present. TxDOT uses Oust®, Escort®, and Arsenal®, all short-term residual materials.

2.1.4 Growth Regulators

TxDOT does not use growth regulators for vegetation management.

2.1.5 Insecticides

Chemicals applied to ant mounds using portable hand sprayers should have no effect on visual quality. Some insecticides are distributed in a bait formulation. While this bait is visible with close inspection, it is for a short period only (usually under two hours). Visual impacts for users of safety rest areas and picnic areas are expected to be negligible.

2.2 Cultural Techniques

Visual impacts from cultural maintenance techniques are not as conspicuous as most other methods since changes tend to occur over time. Existing vegetation is encouraged and enhanced to compete with undesirable species. The goal is to create a healthy plant community of desirable species which can withstand invasion from other plants. This, in turn, will improve the visual quality of the affected area.

2.2.1 Selective Pruning

Selective pruning of trees and shrubs by hand involves cutting portions of, or entire branches from vegetation. If done properly, the plant's natural form and visual quality can be preserved or enhanced by removing diseased and unsightly vegetative parts. Selective pruning can allow sufficient sunlight to penetrate the understory for the benefit of other desirable vegetation. The visual quality of plants can be destroyed by selective pruning if branches are cut arbitrarily, without regard to the natural form of the plant or by not cutting branches flush with the main stem, leaving unsightly stubble.

2.2.2 Competitive Planting

In competitive planting, desirable competitive plants (usually grasses and forbs) are introduced to compete with and help control the spread of undesirable plants. The use of competitive vegetation needs to be planned to avoid adverse impacts such as the elimination of desirable plants, invasion of adjacent properties, and roadside encroachment.

Hydroseeding is an effective method of introducing competitive vegetation where large areas of bare ground exist, such as following construction. It aids in the establishment of vegetative cover for disturbed areas over a short period of time by discouraging undesirable plants from establishing and preventing soil erosion. This minimizes visual impacts of treated areas. Interseeding is the application of seed in existing areas of thin turf. Interseeding is most successful if competition from existing vegetation is reduced. Wildflowers can improve the visual quality of disturbed areas, providing a variety of flowers during the spring, summer and fall months. Some forms of wildflowers such as legumes provide nitrogen-fixing capabilities in soils. This increases the available nitrogen in the soil and improves growing conditions and visual quality of desirable plants. This is a good method of preparing an area lacking in nutrients for establishment of desirable vegetation. Common legumes found in wildflower seed mixes include clovers, trefoil, wild pea and lupines. Wildflowers also provide deep root systems which provide better soil-holding capabilities to prevent soil erosion on steep slopes.

2.2.3 Irrigation

Precipitation is an important factor in determining which plant species can be planted or seeded along roadsides in Texas. While irrigation systems expand the diversity of available plant species for use in roadside plantings the installation of irrigation systems on TxDOT ROWs generally is not practiced. For this reason, native plant species adapted to Texas summer heat and droughts are particularly appropriate for use as roadside vegetative cover.

Irrigation is sometimes used by TxDOT on a temporary basis for initial vegetation establishment on critical areas such as steep slopes. Irrigation can also improve visual quality in small areas by enhancing plant vitality during the dry summer months, however, and is sometimes used in ornamental landscape plantings. Irrigation can dramatically improve visual quality, particularly in urban locations and in areas where public use is high, such as safety rest areas. Improper watering of vegetation through insufficient or overwatering may cause plants to become unhealthy, making them susceptible to diseases. Overwatering can cause soil erosion on sloped areas and negatively impact the overall visual quality of the affected area. It is important to irrigate with water of good quality (e.g. not saline).

2.2.4 Other Techniques

Adding organic mulches to landscape plants can improve growing conditions by increasing the moisture-holding capacity, controlling temperature fluctuations in the soil, and improving plant vitality. This results in healthier-looking plants.

2.3 Biological Techniques

The use of biological techniques to eliminate undesirable vegetation can adversely affect the visual quality of roadside vegetation in the short term. As insects and plant diseases are introduced into a plant community to reduce or eliminate the population of targeted vegetation, host plants may show effects of the treatment over a long period of time and eventually die. Some host plants may not die, but will be greatly weakened, which can initially reduce the visual quality of the affected area. The long-term effects would be the establishment and replacement with desirable plant species, thereby improving the visual quality.

2.4 Mechanical Techniques

Mechanical techniques involve cutting, shearing and blading to reduce or eliminate undesirable vegetation. Visual impacts may vary depending on time of year the practice takes place and which technique is utilized. TxDOT's suspension of summer mowing may bring about an increase in perennial summer wildflowers. Mechanical equipment can improve or damage visual quality. Adverse impacts on visual quality are generally due to improper and inappropriate use of mechanical equipment.

2.4.1 Brush-cutting

Small trees, shrubs, and other vegetation are removed with large brush-cutters, or by hand methods. Small-scale brush removal may have only minimal visual impacts since much of the nearby vegetation is preserved. For large-scale removal, exposed soils and cut stems can be visible until grasses and other low vegetation become established.

Removal of unattractive brush can improve visual quality with minimal impact if it is done progressively.

2.4.2 Brush-shearing

Shearing equipment is used to keep vegetation from encroaching onto the highway and shoulders and to keep drainage courses operational. This method can expose trunks and stems which are easily visible along the entire affected area. Some branches and trunks are not cut cleanly and portions of bark are removed, exposing the lighter wood underneath. Large mowers or brush cutters trim all vegetation to the ground, exposing unprotected soils. The cut material is visible until new vegetation begins to grow. The visual impacts will vary depending on the size of the vegetation and time of year when cutting is performed. Some varieties of brush that are cut in this manner will resprout multiple stems and branches. Plants that can propagate from cuttings can multiply rapidly from pieces that remain on the ground after the cutting operation. The area will soon become overcrowded with plants, increasing the competition for water, nutrients and sunlight, and resulting in stunted growth, the demise of weaker vegetation. This may occasionally reduce visual quality as plants linger in a weakened condition. The visual impacts are greatest soon after cutting when the cut portions are distinctively visible. The effects of cutting performed in early spring will be covered by new growth within a month.

2.4.3 Tree Thinning

Tree thinning is the selective removal of stands of trees or individual trees. Removal of stands of trees can diminish the visual quality of the affected area significantly, particularly to viewers who are familiar with the area. Removal of large stands of trees expose vegetation adapted to shady conditions to direct sunlight and drier soil conditions, making them vulnerable to sunburn. Plants in this situation often turn brown and die, adversely affecting the visual quality. Most thinning processes involve the removal of selected trees within a stand of trees to improve growing conditions and to allow desirable plants to establish. This method will show little disturbance since most of the surrounding vegetation is left intact. This method causes minimal visual impacts.

2.4.4 Mowing - Low Cutting Height

Mowing equipment, used to trim grass and other low-growing vegetation along roadsides, can provide a manicured appearance where required. Proper plant selection and relatively close mowing could benefit safety strips in rural settings. Close mowing can improve visibility along the corridor, near curves, intersections, and in urban areas. Mowing grass at a low cutting height is appropriate for urban areas and service areas such as safety rest areas and bus stops where a manicured appearance would blend in with the adjacent formalized landscape treatment. Frequent mowing can improve the visual quality of lawn and grass areas. However, this method may appear out of character in rural and adjacent natural or sensitive areas. The cut material is usually left in place and can be unsightly until it is concealed by new growth. Leaving the cut grass in place provides, ultimately, a mulch which will diminish the amount of water lost from the soil through evaporation and provide nutrients. In the long term, grass mulched in this manner will be healthier and more visually attractive if quantities left in place are not large enough to smother existing vegetation. Very low cutting heights increase the hazards from mower-thrown objects.

2.4.5 Mowing - High Cutting Height

Grass mown at a relatively high cutting height prevents scalping. Grasses that are cut taller will have less water loss during the summer months. Taller, healthier grass also reduces the chances of invasion of undesirable plants, thereby maintaining the visual quality of the affected area. The taller height is visually appropriate for suburban and rural areas, areas in the passive wildlife zone after nesting, and in some cases, in service areas such as points of interest within natural areas. As cutting height increases, the difficulty in mowing many areas increases.

2.4.6 Unmowed Grass

Grass left unmowed provides a natural meadow which is visually appropriate in rural and natural areas, and in the wildlife passive zone, but out of character in urban and suburban areas. Traditional expectations of lawn-like ROWs can result in some perception by the traveling public that the unmowed portions of the ROWs are unkempt or neglected.

A study in North Dakota in 1971 (Oetting and Cassel), however, demonstrated that public perception of unmowed portions of the ROW became markedly more positive after interviewees were informed of the benefits of maintaining a roadside passive zone for wildlife habitat (TxDOT, 1993). This suggests that publicity programs or roadside signage would increase acceptance of this practice.

2.4.7 Other Techniques

Blading is effective in removing vegetation from shoulders and drainage swales. However, blading exposes soils to erosion and establishment of undesirable vegetation. Complete removal of vegetation in ditches with vegetative cover will result in a denuded appearance.

2.5 Unavoidable Adverse Impacts

Views of maintenance equipment along roadsides will have temporary visual impacts to those utilizing the highway as well as to adjacent properties who have views of the highway corridor. The degree of visual impacts will change from urban areas to natural areas. Observers in urban areas are exposed to numerous vehicles and therefore will notice negligible visual impacts. Observers in natural areas will experience the greatest visual impacts from maintenance equipment as it is a foreign element within the landscape.

Vegetation management activities may cause short-term visual impacts until the vegetation has had an opportunity to fill in or recover from the effects of maintenance management activities.

Appendix A - Chapter 10

Draft EIS
Pest Management Program

1.0 Description of the Highway Facility

Highways typically consist of alternating paved travel lanes and vegetated areas with associated structures, guardrails, signage, pavement delineators, drainage accommodations, vehicle recovery areas, and traveler facilities such as safety rest and picnic areas. These highway elements are designed to facilitate the efficient movement of people and goods, and for maintenance of the infrastructure. The components of a highway facility often require contrasting and specific treatments for pest management.

Highways may be classified as high- or low-volume based on average daily traffic (ADT). For both high-and low-volume highways, a series of alternating vegetated and paved elements comprise the corridor as one moves from ROW boundary to ROW boundary. High-volume routes would consist of interstate, U.S. numbered, state highways, and loops or spurs, and usually have paved shoulders of variable width. Low- volume routes include farm and ranch roads, and park and other recreational roads. These may be constructed without shoulders. High- volume routes have ROW widths of 100-200 feet or more, while low-volume routes would be 50 feet wide.

During construction and after earthwork has been completed to line and grade, the soil surface of a roadside adjacent to travelways as well as that of medians could be stabilized with vegetation, primarily a mix of grasses, legumes, and wildflowers. Over time, woody plants may be planted or encroach. TxDOT manages roadside vegetation in a manner compatible with the level of development of adjacent property (TxDOT, 1993). Urban roadsides are managed intensively, and often use landscape plantings to enhance features such as delineating on- or off-ramps and medians. Rural roadsides are managed extensively; that is, they are managed on a large-scale, less-detailed basis to accommodate the functional needs within the active and passive zones. The active zone consists of Zone 1a, the paved shoulder (if present) and Zone 1b, from the shoulder edge to the centerline of the drainage channel. The passive zone (Zone 2) consists of the vegetated area from the center line of the drainage channel to the ROW boundary (see Figure 1-1 in the Main Body of the DEIS). Zones 1b and 2 usually are vegetated with a mixture of native or adapted plants.

Ideally, the grass turf on a roadside forms a distinct juncture with the edge of the paved travelway. Given the aggressive nature of some roadside plants, however, encroachment onto the travel surface does occur. Encroachment over the pavement occurs by plants extending over the pavement edge, growing through the pavement from underneath, or from germinating seeds lodged in joints or cracks in the pavement. Thus, the same plants which are desirable for the stability of the roadside may also contribute to a premature breakdown of the travel surface. Further, plants on a roadside would be considered pest vegetation if they interfere with sight distance, impede the flow of drainage water, or form a seed reservoir for establishment of undesirable plants on the ROW or in adjacent agricultural land.

There are two primary reasons for a vegetation management system within the highway corridor: first, safety of the traveling public and highway maintenance personnel and second, protection of the capital investment. Safety is enhanced by improved visibility of pavement edges, signage, cross-signage, fixtures, and of cross-traffic. Facilitating drainage of surface water from a wet pavement increases wheel traction and prolongs the life of the travelway. Tall plants in drainage channels interfere with drainage and cause siltation. In the case of noxious weeds, existing hazard plants should be neutralized, and the seed source for these plants should be eliminated to prevent continuing infestation. Protection of the capital investment involves mitigation of undesirable vegetation encroaching into pavement and presuppression of roadside fires.

2.0 Roadside Pest Management Objectives

Roadside pest management is used by transportation agencies to protect public safety and capital investment in the highway corridor. TxDOT's Pest Management Program expands these universal management goals as follows (TxDOT, 1993). Roadside pest management is undertaken to:

- Ensure the safety of highway users and TxDOT maintenance personnel;
- Prevent erosion through the establishment of permananent vegetative cover;
- Enhance environmental protection within and adjacent to the highway corridor;
- Promote and preserve native wildlife habitats and diversity of native flora along roadsides in each of the ten vegetational regions of Texas;
- Promote coordination and efficiency in maintenance activities;
- Increase the pleasure of the driving experience; and
- Suppress the occurrence of wildfires on the ROW, and their spread to adjacent lands.

TxDOT's VMS is designed to achieve these goals in concert with IMS to protect the public in TxDOT traveler facilities and workers engaged in maintenance tasks. While safety is paramount, other objectives such as the restoration of desirable plant communities, biological diversity, and relative increases or decreases in desirable forage or cover for wildlife are achievable within a roadside pest management program. Descriptions of program objectives and activities follow.

Maintenance for Visibility: Unobstructed views of vehicular and pedestrian traffic, pavement edges, highway and fixtures along the ROWs are essential for highway safety. Appropriate sight distances must be maintained to allow roadway users adequate time to respond to changes in the condition of the road ahead.

Maintenance for Drainage: Pavement integrity and user safety depend on adequate drainage of water from pavement areas. Ponding of sheet flow may be a problem if vegetation is permitted to encroach beyond the pavement edge. Water ponding on the roadway may cause operators to lose control of their vehicles from hydroplaning, resulting in the loss of life or property. Ponding also contributes to the failure of the roadway base. Excessive vegetation in drainage channels may impede flow from the pavement, particularly those channels with very flat grades. Potential loss of channel function through vegetation encroachment is a major challenge in roadside maintenance programs.

The maintenance of vegetative cover is essential in areas of rapid drainage, whether sheet (uniform, low volume) or channel (concentrated, higher volume and velocity) flow. Vegetation tends to increase infiltration rates and decrease runoff volume. Decreased runoff volume and velocity reduce erosive effects and improve water quality (Dillaha et al., 1989).

Maintenance for Clearance: In addition to lateral encroachment over the paved surface, vegetation may encroach into airspace above the roadway through normal growth, creating a tunnel effect. For example, tree branches may extend into the space required for the passage of trucks and other large vehicles traveling the roadway. Riparian species sometimes surpass the height of bridge decking or encroach upon the roadway through bridge banisters.

An unobstructed area immediately adjacent to the roadway allows roadway users to make emergency stops or recover control of vehicles leaving the roadway. Tree species with trunk diameters exceeding 10 cm (4 inches) are not permitted in these areas.

Protection of Roadway Integrity: Encroachment of vegetation into pavement accelerates deterioration of these facilities. Vegetation growing in joints or cracks threatens roadbed integrity by funneling water beneath the pavement, which softens and destabilizes roadbed materials. The weakened roadway base allows overlying pavement to become stressed and fail. Vehicles traveling over these stressed areas promote the formation of potholes. Plant growth and freeze/thaw cycles perpetuate the deterioration cycle by hastening the failure of pavement and base.

Control of Erosion: Vegetation plays a major role in preventing soil erosion. Soil erosion along roadways could increase stream sedimentation and risks for aquatic ecosystems, and could result in deposition of sediment on the highway surface and adjoining lands. Excess sediment may clog drainage facilities, requiring more frequent clearing. Extreme erosion could reduce stability of cut and fill slopes, increasing the risk of slope failure. Soil erosion resulting from inadequate vegetation may cause such problems as undermining of the shoulder, roadway, and other structures. Maintaining soil cover is especially important when overstory vegetation is removed to satisfy other prescribed needs. Soil erosion threatens capital investment, increases maintenance costs, scars the landscape, and pollutes the environment.

Control of Noxious Weeds: Noxious weeds are plants classified by the Texas Department of Agriculture as detrimental to agriculture or public health, safety, and welfare. Prevention of the importation of these weeds is accomplished through the seed law, while control of established weeds is the responsibility of the landowner.

In some ROWs, the control of noxious weeds is particularly important, such as those adjacent to pasture or cropland. Noxious weed infestations from seed produced on the ROW could impact the agricultural economy of an individual enterprise, the local area, and the entire state. Most noxious weeds are species adapted to invading disturbed soils. Maintaining a dense cover of native or preferred vegetation would inhibit invasion by noxious weeds.

Reduction of Fire Hazard: Dry vegetation near pavement edges is easily ignited by catalytic converters, mufflers, or discarded smoking materials. Smoke from resulting fires obscures visibility, while fires may damage highway facilities and adjacent properties. The potential for fire varies widely among the regions of the state, depending largely on climate and on type and quantity of fuel. The maintenance of vegetation on a safety strip reduces the risk of fire ignition and slows the spread of fire into outer portions of the ROW and adjacent properties (Hauser and McCully, 1993).

Removal of Hazard Vegetation: Dead or dying limbs, trees, and large shrubs could fall onto the roadway or shoulders, striking vehicles or requiring sudden evasive maneuvers to avoid collision. Such events usually occur during windstorms or periods of heavy rainfall. Ice storms may weigh down and break trees and limbs, causing them to fall onto the roadway. Dead or weakened vegetation on the ROW is susceptible to infection by microorganisms or attack by insects. Invaded vegetation then becomes a host for such organisms, placing the health of the adjacent ROW vegetation at risk.

Aesthetic Maintenance of ROW and Ornamental Landscape Plantings: Both the definition of an attractive roadside and the relative importance granted to maintaining roadside appearance varies widely among individuals and regions. Situations considered unattractive by TxDOT include volunteer vegetation along paved medians and weedy growth in landscaped areas. In addition to its unattractive appearance, this weedy growth competes with the landscape plantings for soil moisture.

Maintenance of Signal Function: Fires ants are known to invade electric signal boxes and strip insulation from wires, causing short circuits and disabling traffic signals (MacKay et al., 1991). It is imperative ants be controlled in signal boxes to faciliate traffic control for the safety of the traveling public and to protect workers servicing these installations.

Protection and Enhancement of the Environment: TxDOT's highways pass through diverse environments, ranging from humid prairies and forest in the southeast and east to desert shrub, grassland, and mountain forests in the west (TxDOT, 1993). TxDOT's pest management goals are to balance the needs of highway users with environmental concerns. Important environmental concerns of pest management include: controlling soil erosion, maintaining water quality, enhancing wildlife habitats, enhancing native vegetation, controling noise, providing a pleasant visual environment, and protecting the health of TxDOT workers and the public.

Establishing desirable vegetation helps control soil loss due to erosion. Planting permanent erosion control vegetation has a direct bearing on long-term vegetation management requirements. It is consistent with roadside maintenance to establish low-maintenance vegetation, either by manipulation of the existing plant community or by actively planting desirable species. Zone 2 of the roadside could be managed to support wildlife and restore biodiversity in a manner that would not conflict with the safe use of the highway. To the extent possible, native vegetation is used along highway ROWs. Where the use of native vegetation is impractical, careful consideration is given to the selection of adopted introduced species to be used in order to ensure they meet TxDOT's needs and to the extent possible do not conflict with ecological concerns.

Some areas are intended for active use by the traveling public (Zones 1a and 1b), while others would integrate the transportation facility into the environment through which it passes (Zone 2). Visual impacts would be important considerations to quality of life for both users and adjacent landowners. Well-maintained vegetation in Zones 1b and 2 of the ROW contribute to the water quality of an area by: 1) preventing soil erosion, 2) acting as a filter by effectively trapping sediment and other pollutants, and 3) slowing the flow of runoff.

3.0 Environmental Consequences of Treatment Methods

3.1 Chemical Techniques

Herbicides could be used to eliminate vegetation which would weaken the structural integrity of the highway and obstruct access to highway appurtenances. Selective treatments affect only targeted plants which are causing the actual damage and vegetation affecting the safety of motorists. Growth regulants reduce growth rates of vegetation, and can be utilized where frequent vegetation management is required to maintain adequate sight distances such as at intersections, curves, and recovery areas.

3.2 Cultural Techniques

Competitive plantings would enhance the density or vigor of desirable plants which, in turn, would discourage establishment of undesirable plants. This is important where adequate sight distances would be required and where soil erosion may be of concern. Native plant communities could be re-established along ROWs using cultural techniques. This would provide excellent habitat cover in Zone 2 and restore Texas' native biodiversity.

Site preparation, selecting native or adopted planting materials, and installing a surface mulch are prerequisites to securing a good stand.

3.3 Biological Techniques

There are no known adverse consequences to structural integrity of the highway or to public safety from the use of biological techniques.

3.4 Mechanical Techniques

Selective pruning is a labor-intensive method of vegetation management. It is utilized where the use of mechanized equipment is not feasible, such as in providing adequate height clearance of tree branches above roads and sidewalks and maintaining ornamental plants. It also is utilized to remove dead and dying vegetation which could be hazardous to the traveling public.

Mowing is an effective but short-term method of controling vegetation to maintain adequate sight distances. Mowing activities could, however, impact the operational safety of motorists because of the close proximity of mowers to the edge of the travel way. Mower-thrown objects can strike users of the roadway or TxDOT personnel. Brush removal, done on a small scale by cutting or blading, will have little adverse effect on the structural integrity of the highway and to public safety. However, if done on a large scale and without subsequent revegetation, soils may be exposed to erosion and promote invasion of undesirable plants. Stubble left after cutting operations could compromise the safety of the highway by producing sharp, fixed objects which could injure the traveling public and wildlife.

3.5 Unavoidable Adverse Impacts

Mechanical equipment may temporarily block passage of vehicles, bicycles, and pedestrians during vegetation management activities. If dust and debris impact the operational safety of the highway, traffic control procedures should be used.

Appendix A - Chapter 11

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Pest Management Program

1.0 Introduction

Visual aids, such as striping, signs, guardrails, delineators, and lighting assist roadway users in their highway travel. They protect the public from potential hazards, warn users of changing conditions ahead, and allow enough time for users to take appropriate action. Pest management ensures the functioning of these fixtures in protecting the health, safety, and welfare of the traveling public.

1.1 Traveler Facilities

Traveler facilities along the highway include bus stops, safety rest areas, picnic areas, points of interest, and shoulder turnouts. Pest management is vitally important to public safety and the public image of TxDOT and the State of Texas.

Aside from fixtures, which number several per mile along the full length of the highway system, formal traveler facilities are strategically placed throughout the state to ensure the comfort and safety of the traveling public.

1.1.1 Bus Stops

Bus stops provide an area where people load and unload from public buses or school buses. Pest management in these areas considers the light available to these areas during hours of darkness and visibility needs of buses. Providing adequate visibility of passengers waiting at the bus stops and adequate visibility for bus drivers to re-enter the highway are important functions of vegetation management. Treatment of ant mounds may be necessary in some areas for the safety of travelers.

1.1.2 Safety Rest Areas and Picnic Areas

Safety rest areas and picnic areas provide places where vehicles can leave the highway to allow motorists and passengers a restorative break from their travel.

These facilities are used extensively during holidays, during tourist seasons, and, to a lesser degree, through the remainder of the year. Pest management in these facilities must satisfy the usage of the facilities, as well as project a positive public image. Adequate visibility to ingress and egress is an important function of vegetation management. Visibility into the rest area sometimes is important for security and public safety reasons. Control of infestations of ants and other insects (wasps, spiders, etc.) is essential in safety rest areas.

1.1.3 Points of Interest

Scenic views and historical markers provide information about a given area to roadway users. Points of interest are essential elements for tourism. Adequate sight distance to and from points of interest is necessary to safely maneuver vehicles into the service area and return onto the highway. Vegetation management around interpretive information signs, benches, waste receptacles, restroom facilities, and walls/barriers should be done in a manner which will not compromise the use and image of these facilities.

1.1.4 Shoulder Turnout

Shoulder turnouts provide areas along the highway where motorists pull off the highway for emergency situations. Vegetation management should provide adequate visibility to allow motorists to recognize the facility and take appropriate action.

2.0 Environmental Consequences of Treatment Methods

Traveler facilities can be classified as high-contact areas for the traveling public. Traveler facilities are used by a large number of people, especially during peak travel seasons. Some traveler facilities, such as bus stops and safety rest areas are utilized year-round. If possible, significant vegetation management activities should be planned to avoid peak seasons or hours of high use to keep these facilities operational.

2.1 Chemical Techniques

There is some chance of public exposure to pesticides in traveler facilities. The human health risk from this exposure is minimal, and is discussed in Appendix B. In locations where visitors could come into direct contact with applied pesticides, a common sense approach to chemical applications will prevent most, if not all, possible adverse affects to the well-being of the public. Workers should cordon off areas to be treated before chemical application and apply the chemical according to label directions. Chemicals should be applied during periods of lightest public use.

2.2 Cultural Techniques

Cultural techniques decrease the need for chemical and mechanical techniques and, thereby, reduce the negative environmental impacts associated with these methods of vegetation management.

2.3 Biological Techniques

Insects and plant diseases used as biological controls are carefully tested before they are approved for use. Biological controls are species-specific and will not harm other species. No adverse environmental impacts are anticipated from the use of biological techniques.

2.4 Mechanical Techniques

Mechanical techniques which cut woody vegetation can expose sharp ends of stems and branches which may cause serious injuries to the public. Injuries to the public may occur from projectiles and falling debris during the operation of mechanical equipment. The use of traveler facilities can be compromised by fumes, odors, and noises associated with mechanical equipment.

2.5 Unavoidable Adverse Impacts

During emergency situations where mechanical equipment is utilized, the users of these facilities may be temporarily inconvenienced. Also, the character and visual quality of the facilities may be temporarily compromised by noise, odors, dust, and debris generated by maintenance equipment or other users.