Final

Lower Rio Grande Valley and Santa Ana National Wildlife Refuges

Interim Comprehensive Management Plan

September 1997

U.S. Fish and Wildlife Service
U.S. Department of the Interior

Cover Artwork by Brian Cobble

U.S. FISH AND WILDLIFE SERVICE
ENVIRONMENTAL ACTION MEMORANDUM

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA) and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and have determined that the action of: Approval and Implementation of the Interim Comprehensive Management Plan for the Lower Rio Grande and Santa Ana National Wildlife Refuges,

______ is a categorical exclusion as provided by 516 DM 6 Appendix 1 section B(4). No further documentation will be made.

______ is found not to have significant environmental effects as determined by the attached Environmental Assessment and Finding of No Significant Impact.

X_____ is found to have special environmental conditions as described in the attached Environmental Assessment. The attached Finding of No Significant Impact will not be final nor any actions taken pending a 30 day period for public review (40 CFR 1501.4(e)(2)).

_____ is found to have significant effects, and therefore a "notice of Intent" will be published in the Federal Register to prepare an Environmental Impact Statement before the project is considered further.

_____ is denied because of environmental damage, Service policy, or mandate.

_____ is an emergency situation. Only those actions necessary to control the immediate impacts of the emergency will be taken. Other related actions remain subject to NEPA review.

Other supporting documents: **Finding of No Significant Impact, Environmental Assessment for the Interim Comprehensive Management Plan (CMP) for the Lower Rio Grande Valley NWR and Santa Ana NWR, and Interim CMP for Lower Rio Grande Valley and Santa Ana National Wildlife Refuges..**

Lynn B. Starnes 9/24/97
Director/Regional Director Date

(1) Kenneth F. Merritt 9/22/97
Initiator Date

(2) Lynn B. Starnes 9/24/97
Texas GM Date

Finding of No Significant Impact

Environmental Assessment and Interim Comprehensive Management Plan for the Lower Rio Grande Valley & Santa Ana National Wildlife Refuges

The U.S. Fish and Wildlife Service has developed an Interim Comprehensive Management Plan (CMP) for the Lower Rio Grande Valley and Santa Ana National Wildlife Refuges. Through an extensive program of consultation and public involvement, the Service has outlined the various problems and opportunities (i.e., issues) confronting the refuge. The CMP and the Environmental Assessment outline these issues programmatically and how the Service intends to address them over the next 5 to 10 years.

Implementation of the CMP constitutes a formalization of a set of proposed programmatic comprehensive management goals,objectives, and strategies for both the Lower Rio Grande Valley NWR and Santa Ana NWR. Based on a review and evaluation of the information contained in the CMP and the Environmental Assessment, I have determined that the formal approval of refuge public use goals and objectives as described in the Proposed Alternative of the Environmental Assessment, is not deemed a major Federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2) (c) of the National Environmental Policy Act (NEPA). Therefore, an Environmental Impact Statement is not required. However, it is the intent of the Service to revisit questions of potential significant environmental consequences in accordance with NEPA upon consideration of the implementation of site specific proposals called for and discussed in the final plan document.

Lynn B Starnes — 9/24/97

Regional Director, Region 2 — Date
U.S. Fish and Wildlife Service

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COMPREHENSIVE MANAGEMENT PLAN APPROVAL
for the
Lower Rio Grande Valley NWR & Santa Ana NWR
1997

The attached Comprehensive Management Plan for the Lower Rio Grande Valley NWR and Santa Ana NWR has been reviewed and approved by the manager of the aforementioned National Wildlife Refuges.

Submitted by:

Kenneth L. Merritt for
Larry Ditto, Complex Project Leader
Lower Rio Grande Valley NWR &
Santa Ana NWR

9/22/97
Date

Approved by:

Lynn B Starnes
Lynn Starnes, Geographic Manager - Texas

9/24/97
Date

Approved by:

Lynn B Starnes
for **Nancy Kaufman**
Regional Director, Region 2
U.S. Fish and Wildlife Service

9/24/97
Date

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VISION

Few wild places in the Western Hemisphere exhibit such a diversity of flora, fauna and geomorphic conditions as the lower Rio Grande Valley in south Texas. Its remnant natural habitats thrive along side social and economic activities. This can be a great advantage over the next twenty years if conservation and development activities are well coordinated. Still, few wild places have the opportunity for recovery from the brink of extinction. The Lower Rio Grande Valley and Santa Ana National Wildlife Refuges include some of the last parcels of subtropical thorn forests in the U.S. and they represent the best chance for their protection and recovery. Ultimately, they will help form a functioning corridor to sustain the unique flora and fauna of the Texas/Mexico border.

The Lower Rio Grande Valley Refuge will someday be 132,500 acres of mostly contiguous tracts of natural brush, reforested farmlands and wetlands. The future is one of land acquisition, habitat restoration, wetland recovery, and compatible wildlife dependent recreation where the American public can enjoy this rare treasure. Santa Ana NWR will continue to be a national model by providing compatible high quality wildlife-dependent visitor opportunities. These opportunities will be well-balanced with effective monitoring and protection of wildlife and habitat values.

Wildlife abundance and high quality facilities will attract thousands of visitors annually. Partners will collaborate to provide an array of environmental programs and related activities. Local communities will enthusiastically identify and promote the area as a regional tourist destination that contributes to the economy and enhances the quality of life.

Executive Summary

The Interim Comprehensive Management Plan for the Lower Rio Grande Valley NWR will serve as a management tool to be used by the Refuge staff in the preservation and restoration of the ecosystem's natural resources. In that regard, the plan will guide management decisions over the next five to ten years and set forth strategies for achieving Refuge goals and objectives within that time frame.

The results of the planning process are perhaps best summarized by five major Refuge goals that are supported by a series of objectives and specific implementation strategies. Those goals include:

GOAL I: Protect Biological Diversity, Land and Waters

To restore, enhance and protect the natural diversity of the Lower Rio Grande Valley including threatened and endangered species on and off refuge lands, through

- Land acquisition;
- Management of habitat and wildlife resources on refuge lands;
- Strengthening existing, and establishing new cooperative efforts.

GOAL II: Protect Water Rights, Water Management and the Management of Wetlands

To protect existing water rights holdings, improve the efficiency of water delivery systems, protect, enhance, and rehabilitate refuge wetlands.

GOAL III: Protect and Improve Water Quality

Improve refuge water quality and reduce contaminant related fish and wildlife resource losses.

GOAL IV: Protect Cultural Resources

To protect, maintain, and plan for Service managed cultural resources on the Lower Rio Grande Valley NWR for the benefit of present and future generations.

GOAL V: Provide compatible wildlife dependent public uses, recreational opportunities, interpretation and education.

- Continue to offer a quality wildlife observational trial system on Santa Ana NWR

- Offer compatible wildlife dependent public access on certain tracts of the LRGV NWR

- Continue wildlife interpretation and educational efforts at Santa Ana NWR and initiate interpretive efforts for LRGV NWR in coordination with private groups and other jurisdictions.

1.0 Introduction and Regional Setting

This interim Comprehensive Management Plan (CMP) focuses primarily on the Lower Rio Grande Valley (LRGV) National Wildlife Refuge Complex (Refuge Complex). The Complex is comprised of the Lower Rio Grande Valley National Wildlife Refuge and the Santa Ana National Wildlife Refuge. The Refuge complex falls within the larger Lower Rio Grande Ecosystem and specifically the Tamaulipan Province's Matamoran District. For purposes of this plan, it is this smaller area that is considered to be the Area of Ecological Concern.[1]

This plan is considered as an interim plan to cover a period of 5 to 10 years as opposed to the usual 20 year period for most CMP efforts. Long term efforts are continued to be focused on acquisition of lands to complete the original Land Protection Plan developed in 1980. It is anticipated that by the time the 5 to 10 years planning horizon is reached, enough land will have been acquired to warrant a longer term management plan looking beyond the year 2020.

1.1 LRGV Challenges

The Lower Rio Grande Valley (LRGV) is not actually a "valley", but a delta gently sloping away from the Rio Grande.[2] In the LRGV, Tamaulipan brush land, characterized by dense thorn scrub, is considered a unique ecosystem found nowhere else in the United States .[3] The combination of climate, geology, vegetation, and wildlife creates tremendous biological diversity. Many organisms found in the LRGV occur nowhere else in Texas or the United States. Two major flyways, the Mississippi and the Central, come together north of the LRGV funneling millions of birds each spring and autumn to this stopover pinched between the Gulf Coast and the desert to the west. This area supports an abundance of neotropical migratory songbirds, mammals, snakes, lizards and salamanders and contains many rare and unique plant and animal species, many of which reach the northernmost limits of their distribution in the LRGV. Approximately 18 Federally listed threatened and endangered species are found in the LRGV. In addition several plant species are being proposed for listing as endangered species.

Since the 1920's, it is estimated that approximately 95% of the original native brush land in the LRGV has been cleared or altered for agriculture and urban development. It has been estimated that more than 99% of the riparian vegetation on the U.S. side of the Rio Grande has been

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[1]An Area of Ecological Concern can be defined as: "An essentially complete ecosystem (or set of interrelated ecosystems) of which one part cannot be discussed without considering the remainder." [*Malheur National Wildlife Refuge Master Plan and Environmental Assessment*, 1985, p.7] For purposes of this plan the Matamoran District of the Tamaulipan Biotic Province is considered the Area of Ecological Concern. This AEC is administratively and ecologically part of the larger Lower Rio Grande Valley Ecosystem, a Service designation based upon watersheds.

[2]Jahrsdoerfer, S.E. and D. M. Leslie, Jr. 1988. Tamaulipan brush land of the Lower Rio Grande Valley of South Texas: description, human impacts, and management options. Biological Report 88(36). U.S. Department of the Interior, Fish and Wildlife Service. 63 pp.

[3]Collins, K. 1984. Status and management of native south Texas brush lands. U.S. Fish Wildl. Serv., Ecol. Serv., corpus Christi, TX. 18 pp.

cleared. Losses to fish and wildlife resources in the LRGV have resulted from agriculture related practices such as brush clearing, extensive pesticide/herbicide use, and irrigation system development. Construction of Falcon Dam, Retamal Dam, and Anzalduas Dam for flood control, irrigation, and municipal uses, has eliminated regular periodic flooding of the delta woodlands and wetlands and encouraged clearing of native brush for agriculture. In addition, urban and industrial developments have contributed to the loss of native brush land and wetland degradation and elimination, and are likely to continue as the population of the LRGV increases and major industrial development occurs as a result of the passage of the North American Free Trade Agreement (NAFTA).

In 1979, the Service initiated a long-term program of acquiring LRGV lands for inclusion in the National Wildlife Refuge System. This land protection plan was designed to protect the remnants of existing native habitat to form a riparian corridor for plants and wildlife. Additionally, the project called for the reclamation of acquired agricultural lands in order to reestablish native habitats for the benefit of the native plant and wildlife resources throughout the Area of Ecological Concern. Land acquisition continues to be the emphasis for the LRGV land protection program. Of the 132,500 acres proposed for acquisition, approximately 66,000 acres are currently under management by the LRGV National Wildlife Refuge. However, the need for a longer term plan focused on resource management has become an essential and ever increasing requirement for the enhancement and continued protection of fish and wildlife resources. It is important that Service lands be managed for the benefit of the continuum of ecological processes and not just individual geographic entities.

2.0 Planning Perspectives and Considerations

2.1 National Wildlife Refuge System

The Service is the principal agency responsible for conserving, protecting, and enhancing fish and wildlife and their habitats. The Service manages a diverse network of more than 500 National Wildlife Refuges, a System which encompasses 92 million acres of lands and waters. National Wildlife Refuges are set-up for specific purposes and provide habitat for thousands of species of birds, mammals, fish, and insects. Other refuges within the area include Aransas NWR near Corpus Christi, Texas and Laguna Atascosa NWR near Harlingen, Texas.

2.2 The Service & Ecosystem Management

While this plan focuses primarily on Service lands within the Area of Ecological Concern, there is a larger defined area following the Rio Grande from El Paso to the Gulf of Mexico. It is one of 52 ecosystems within the United States designated by the Service based primarily upon watershed designations. The Lower Rio Grande Watershed from El Paso to the Gulf of Mexico is now considered to contain several biomes endemic to the desert, riparian nature of the Rio Grande. The Lower Rio Grande Ecosystem is very long and encompasses a series of biotic provinces including: the Chihuahuan, Balconian, and Tamaulipan biotic provinces.

Based upon a broad set of issues present throughout the entire defined Ecosystem, the Service has developed some broad goals. These Ecosystem goals include: (1) Stewardship to protect and enhance biological diversity and the environment by developing and implementing a Lower Rio Grande Ecosystem Plan; (2) Improve and protect air quality and the quantity and quality of water in the Lower Rio Grande Ecosystem; (3) Conserve bay and estuarine habitat within the Lower Rio Grande Ecosystem; and, (4) Promote public outreach and information dissemination.

2.3 Refuge Complex and Management Districts

The Lower Rio Grande Valley Refuge Complex includes the Santa Ana NWR (2,088 acres) and lands purchased or acquired as conservation easements, and then incorporated into the Lower Rio Grande Valley NWR (64,149 acres). As the project boundary extends approximately 275 river miles from the Gulf west to Falcon Dam on the Rio Grande, it is essential to understand management operations in smaller regional components wherein the more than 100 refuge tracts lie. The refuge complex is divided into the following components or districts: Starr County District, South Hidalgo County District, North Hidalgo-Willacy District, and Cameron County Districts.

2.4 Laguna Atascosa NWR -- A Partner with LRGV NWR

Laguna Atascosa NWR is the third federal refuge in the immediate area and comprises some 45,000 acres in the coastal section of Cameron County. Some LRGV NWR tracts are now located within a few hundred yards of Laguna as parts of planned habitat corridors connecting Laguna to the Rio Grande. Laguna and LRGV complex personnel cooperate in wildlife research and surveys, habitat restoration, exchange of equipment, water management, fire control and law enforcement.

2.5 Planning Perspectives

This interim management planning effort will integrate four perspectives so that the management direction over the next 10 years will produce holistic management approaches for the refuge lands, and to the degree cooperative ventures permit, the LRGV Area of Ecological Concern.

(1) A natural resource sustainability perspective for the Area of Ecological Concern that relates the Service's commitment to fish and wildlife conservation through protecting and restoring biome and ecosystem functions, structure, and species composition while still providing for sustainable socioeconomic use;

(2) A broad perspective for LRGV Area of Ecological Concern issues; (i.e., contaminants, revegetation, endangered species and biological diversity, recreational use, water quality, inter-jurisdictional cooperation, socioeconomic considerations, etc.);

(3) A more focused perspective for national wildlife refuge related policy issues which affect the Lower Rio Grande Valley NWR Complex programs; (water rights, compatibility, endangered species management, etc.) and,

(4) A focused perspective for refuge-specific habitat and wildlife management activities and strategies affecting Management Districts.

An understanding of these four perspectives and the relationship between them lead to the formulation of an integral set of refuge goals, objectives, and management actions/strategies for the next 5 to 10 years.

2.6 The Issues

The following is a list of the general issues that confront the Lower Rio Grande Valley NWR Complex programs. Goals and objectives have been designed to effect habitat restoration and protection of existing habitat for the benefit of a diversity of wildlife including endangered species.

1. Biological Diversity, Wildlife, and Habitat Management
   - Land Acquisition
   - Scientific Data
   - Endangered Species Management

Revegetation and Habitat Management
fire management
law enforcement
cultural resources

2. Water Rights and Management of Wetlands
3. Water Quality, Contaminants
4. Cultural Resources
5. Public Use, Recreation, and Wildlife Interpretation & Education

2.7 The Need for Action

The Service's Refuge Manual states that the purpose of comprehensive management planning is to "provide long range guidance for the management of national wildlife refuges." [4 RM 1.1, Planning] Because (1) the refuge consists of many separate tracts of land dispersed throughout a four county area, (2) other agencies and entities are involved in land and natural resource management in the same area, (3) the multitude of management needs arising as additional lands are acquired, and (4) the increasing urban, international, and economic development pressures, it has become necessary to coordinate major natural resource decisions. This results in an ecosystem management approach rather than decision-making that would benefit only one particular resource over another. Planning provides a road map to facilitate the kind of coordination that is necessary to enhance the efficiency of implementing management actions designed to benefit the LRGV NWR, Santa Ana NWR, and the Area of Ecological Concern. The Service's approach will be to offer management goals, objectives, strategies/ management actions that are consistent with ecologically desirable outcomes for the entire Lower Rio Grande Ecosystem.

2.8 Expected Planning Outcomes

The following objectives were designed to be consistent with the Service Manual's comprehensive management planning objectives. The planning effort should bring about the following outcomes:

(1) The planning effort will ensure that legal mandates and national direction are incorporated in the management of the Lower Rio Grande Valley Refuge Complex:

(2) The planning effort should determine the capability of the Refuge Complex to further Service and Refuge System goals, objectives, and long-range plans and to provide a means of evaluating accomplishments;

(3) The planning effort should provide a systematic process for making and documenting refuge decisions.

(4) The planning effort should establish broad management strategies that are to the degree possible, consistent with the ecosystem perspective for the Lower Rio Grande Valley, and should guide the refuge management programs and activities consistent with an ecosystem perspective;

(5) The planning effort should provide continuity in the management of the Refuge Complex;

(6) The planning effort should provide a practical basis for budgeting requests to implement management programs leading to the achievement of refuge objectives; and,

(7) The planning effort should achieve an optimum level of public acceptance and/or support for the management strategies adopted through effective involvement in the planning process.

2.9 Public Involvement

A total of six public meetings were held to discuss issues and gather input. The meetings were held beginning July 11, 12, and 13, 1995, in Brownsville, Weslaco, and Rio Grande City, Texas. Additional meetings were held on February 27, 28, and 29, 1996, in Brownsville, Weslaco, and Roma, Texas respectively. Comments were recorded during these meetings. Additionally, written comments were accepted by the Service throughout the planning process and will continue to be received.

Additionally, since the inception of the Service's land protection, (acquisition and management) efforts, the Service has been active in reaching out to the public in general as well as to various conservation groups in an effort to establish a level of public acceptance and education concerning the overall Rio Grande Corridor project and the Service's contributions to that effort. As this plan will be updated periodically, the Service will continue to solicit public input and recommendations regarding program management and efforts.

3.0 Ecosystem and Refuge Resource Description

The Rio Grande originates in the Rocky Mountains of southwestern Colorado and travels approximately 1,885 miles through portions of Colorado, New Mexico, and Texas before emptying into the Gulf of Mexico below Brownsville, Texas and Matamoros, Mexico. In Texas, the Rio Grande forms the international boundary between the United States and Mexico for approximately 1,254 miles. The last two hundred miles of the Rio Grande, located between Falcon Dam and the Gulf of Mexico, form the southern boundary of the Refuge Complex. It is the only river entering the Gulf of Mexico west of the Mississippi that is large enough to have developed a delta of classic proportions. The delta begins approximately 85 miles above the mouth of the river, and fans out symmetrically to include approximately 100 miles of the Gulf Coast. It disrupts the western Gulf pattern of offshore bar islands and coastal lagoons, separating the Laguna Madre of southern Texas from the Laguna Madre of northern Tamaulipas. The delta tributaries and their flood plains are mainly in Cameron, Willacy, and Hidalgo Counties of Texas, and in the municipalities of Matamoros, Valle Hermoso, Rio Bravo, and Reynosa Tamaulipas.

During the present century, most of the area has been cleared of vegetation and leveled for use in irrigation agriculture. The flow of the river has been greatly reduced by pumping for irrigation and by construction of upstream dams and reservoirs on the Rio Grande and its major tributaries. Prior to these changes the river often flooded large areas of the delta depositing new layers of silt. It was the fertile delta soil, aided by these periodic silt-bearing overflows, that made possible the heavy growth of jungle; but because of the limited rainfall between floods, and occasional prolonged drought, only plants adapted to semidry conditions could survive.

3.1 LRGV Area of Ecological Concern General Description

For management reasons, the Lower Rio Grande Valley Area of Ecological Concern boundaries follow those defined as the Matamoran District of the Tamaulipan Biotic Province of southern Texas and northeastern Mexico as described by Blair. The Matamoran District includes Cameron, Hidalgo, Starr, and Willacy Counties of extreme south Texas, commonly referred to as the Lower Rio Grande Valley of Texas. In adjacent portions of Tamaulipas, the *Municipios* of Matamoros, San Fernando, Valle Hermoso, Río Bravo, Reynosa, Díaz Ordaz, Camargo, Miguel Alemán, Mier and Guerrero also pertain to this ecological district. Blair describes the Matamoran District as follows:

> *The southern part of the province in Texas is poorly drained...The brushlands of the Lower Rio Grande Valley, in Cameron, Willacy, Hidalgo, and Starr Counties, are more luxuriant than the brushlands farther south, and they are characterized by the predominance of several species of plants that decrease in abundance northward. The most important of these species include: Retama (*Parkinsonia aculeata*), Texas ebony (*Siderocarpos flexicaulis*), wild olive*

*(*Cordia boissieri*), and knackaway (*Ehretia elliptica*). The most luxuriant brush occurs on the immediate flood- plain of the lower Rio Grande. Large elms (*Ulmus crassifolia*) dominate the flood-plain in some places, and there is usually an alternation of elm dominants and brush species.*[4]

In addition to the management of natural resources on Service lands in this area of ecological concern, natural resource management is carried out by the Texas Parks and Wildlife Department, local governments, Frontera Audubon Society, National Audubon Society, The Nature Conservancy and private land owners. These landowners work in partnership with state and federal programs and play important roles, through conservation easements and in the enhancement and protection of wetland resources. Other organizations that are involved in preservation of Tamaulipan brushland include the Valley Nature Center, Valley Land Fund, The Texas Organization of Endangered Species, Native Plant Project, Lone Star Chapter of the Sierra Club, and others.

3.2. Biotic Communities Designations for Land Acquisition

The Service has adopted a biotic community approach to land acquisition within the LRGV area of ecological concern. This community-based acquisition plan establishes goals only for the Lower Rio Grande Valley NWR Complex. However, it is also intended to help coordinate land protection and management efforts between the Service and the other Federal, State, Mexican and private partners in the Wildlife Corridor project.

Eleven communities, as summarized below, have been prioritized for land acquisition. These community boundaries are based on historical information, soil types, hydrology, and existing natural vegetation, but not on administrative concerns, political jurisdictions or land ownership. Section 3.2.1 provides a more detailed description of the major plant communities within the area of ecological concern. It is emphasized that ecological communities are not themselves discreet entities, but concepts defined by biologists to describe natural associations of organisms within their physical environment. These definitions vary, depending on the point of view of the observer. Consequently, there are both similarities and differences between these communities that have been designated for land acquisition purposes, and other published ecological descriptions of this region.

Summary of Land Acquisition Biotic Community Designations for the LRGV Area of Ecological Concern.

1. **Clay Loma/Wind Tidal Flats**. A matrix of clay dunes interspersed within the saline flats, marshes and shallow bays bordering the Gulf of Mexico. Typical plants are sea ox-eye (*Borrichia frutescens*), saltwort (*Batis maritima*) and glasswort (*Salicornia sp.*)

[4]Blair, W.F. 1950. The biotic provinces of Texas. Tex. J.Sci. 2(1):930117. (LD).

on the vegetated portions of the flats, and gulf cordgrass (*Spartina spartinae*), Berlandier's fiddlewood (*Citharexylum berlandieri*), Texas ebony (*Pithecellobium ebano*) and yucca (*Yucca treculeana*) on the higher lomas.

2. **Coastal Brushland Potholes**. An area of dense brushy woodland surrounding freshwater ponds and shifting to low brush and grasslands around brackish ponds and saline estuaries nearer the Gulf of Mexico. Areas of both active and stable sand dunes are found here. Typical plants are honey mesquite (*Prosopis glandulosa*), granjeno (*Celtis pallida*), barbed-wire cactus (*Acanthocereus pentagonus*) and gulf cordgrass. These wetlands receive heavy use by migratory waterfowl.

3. **Sabal Palm Forest**. A very diverse riparian forest located along the Rio Grande in the Texas southmost area (south and east of Brownsville). The forest is dominated by Texas sabal palm (*Sabal texana*) with Texas ebony, tepeguaje (*Leucaena pulverulenta*), David's milkberry (*Chiococca alba*), anacua (*Ehretia anacua*), brasil (*Condalia hookeri*) and granjeno among many other important plants. The original palm forest has been reduced to less than 50 acres from an estimated original total of 40,000 acres or more. Several tropical plant and animal species occur here.

4. **Mid-Valley Riparian Woodland**. This community is essentially a tall, dense, canopied bottomland hardwood forest comprised mainly of Rio Grande ash (*Fraxinus berlandieriana*), sugar hackberry (*Celtis laevigata*), black willow (*Salix nigra*), cedar elm (*Ulmus crassifolia*), Texas ebony and anacua. This habitat is particularly favored by chachalacas and green jays.

5. **Mid-Delta Thorn Forest**. This plant community which once covered much of the Rio Grande delta has been reduced to a few tracts of less than 100 acres and remnant strips along fence rows, canals and ditch banks. Honey mesquite, Texas ebony, coma (*Bumelia celastrina*), anacua, granjeno, colima (*Zanthoxylum fagara*) and many other shrubs and small trees form a dense thicket which provides excellent wildlife habitat. This is a favored site for white-winged dove nesting colonies.

6. **Woodland Potholes and Basins**. Lighter soils and numerous small seasonal fresh water wetlands and playa lakes characterize this region. Also here are the unique large hypersaline lakes of La Sal Vieja, La Sal Blanca and La Sal del Rey which host thousands of migrating shorebirds as well as nesting terns and black skimmers (*Rynchops niger*). All the wetlands are set in low woodlands of honey mesquite, granjeno, prickly pear (*Opuntia lindheimeri*), lotebush (*Ziziphus obtusifolia*), elbow bush (*Forestiera angustifolia*) and brasil. Ocelots are found here in the denser thickets.

7. **Upland Thorn scrub**. This is the most widespread habitat type in the Tamaulipan Biotic Province and occurs on higher and dryer sites to the north and west of the Rio

Grande Delta. Typical woody plants are anacahuita (*Cordia boissieri*), cenizo (*Leucophylum frutescens*) and palo verde (*Cercidium texanum*).

8. **Barretal**. Barreta (*Helietta parvifolia*) is a small tree related to citrus which occurs in the U. S. only on gravely caleche hilltops along the Bordas Escarpment. Other plants typical of this unique ecotone are palo verde, guajillo (*Acacia berlandieri*), blackbrush (*Acacia rigidula*), anacahuita, yucca and many species of cacti.

9. **Upper Valley Flood Forest**. The floodplain becomes narrower and narrower above Mission, Texas with river bank stands of Rio Grande ash, cedar elm, sugar hackberry and black willow often shifting to honey mesquite, prickly pear and granjeno within a short distance from the river. This area is excellent habitat for many species of USFWS management concern.

10. **Ramaderos**. Arroyos and smaller drainages extend for miles away from the river through arid lands. These areas with higher moisture and deeper soils are corridors of much more mesic vegetation which serve wildlife as travel lanes and as refuges of food and cover particularly during times of drought.

11. **Chihuahuan Thorn Forest**. This area below Falcon Dam includes a very narrow riparian zone and a desert shrub community on the uplands. Several endangered or rare plants occur in this area such as Montezuma baldcypress (*Taxodium mucronatum*) and Johnston's Frankenia (*Frankenia johnstonii*). Several uncommon birds such as the brown jay (*Cyanocorax morio*), ringed kingfisher (*Ceryle torquata*) and red-billed pigeon (*Columba flavirostris*) are most often seen here.

3.2.1 Description of Vegetation in the Area of Ecological Concern.

The nature and extent of vegetation types prior to Spanish colonization is subject to speculation, especially regarding the brushland-grassland ecotone. In many regions of North America, Native Americans altered landscapes through prescribed burning; frequent fire favors grasses over woody plants. Salinas[5] compiled numerous references from Spanish archives regarding the region's Native American populations. These possibly disparate peoples are sometimes generically referred to as the Coahuiltecans and the Karankawas.[6] Their small, roving bands of hunter-gatherers apparently did use fire to herd or entrap game. Unfortunately, the Coahuiltecan cultures and languages were quickly eradicated, so it is difficult to determine what impacts they had on vegetation. Cabeza de Vaca was certainly the first European to traverse south Texas, but it is impossible to determine exactly where he

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[5] Salinas, M. 1990. Indians of the Rio Grande Delta: Their Role in the History of Southern Texas and Northeastern Mexico. University of Texas Press, Austin, Tx. 193 pp.

[6] Newcomb, Jr., W. 1993. The Indians of Texas: From Prehistoric to Modern Times. University of Texas Press, Austin, Tx. 404 pp.

turned inland from the Gulf coast.[7] The first scientific observations of this region were recorded by Berlandier in 1828, nearly 80 years after Escandon's settlements were established.[8] Inglis investigated historical accounts of travelers through south Texas, which yield many valuable insights.[9] Clover's *Vegetational Survey of the Lower Rio Grande Valley, Texas* provided a plausible scenario for the pre-settlement vegetation of the region.[10] Johnston's *Past and Present Grasslands of Southern Texas and Northeastern Mexico* continues to be the definitive work on the composition and location of prairie and savanna plant communities in this region.[11] In addition to historical evidence, existing scattered remnants of relatively undisturbed habitat help us understand how the vegetation of the delta must have appeared before European colonization.

Based on these sources, we can infer a reasonably accurate general description of the major vegetation types of the area of ecological concern at the time of European colonization. Along the coastal corridor, as well as specific inland sites, vegetation types are strongly correlated to soil salinity gradients. The prevailing southeasterly wind and tidal surges bring salts several miles inland. Salinity collects in low-lying mud flats devoid of vegetation, bordered by saline marshes of halophytic succulents, like *Suaeda, Borrichia* and *Salicornia*, and thickets of dwarfed black mangrove (*Avicennia germinans*). Extensive *sacahuistales* (cord-grass prairies) occupy zones of intermediate salinity. These halophytic communities are interspersed with *Lomas* (dunes of wind-blown clay). Rainwater leaches the high salinity levels from the *Lomas*, creating a shallow, perched rooting zone that supports a high diversity of native grasses, cacti and a very dense, low shrub community. The *Loma* vegetation is essentially the same as coastal brushland, which forms at the margins of saline zones. The plant species composition of the *Lomas* and coastal brushland is similar to the brushlands found further inland. However, the higher rainfall along the coast, and the perched rooting zone, result in an extremely dense but low vegetation structure. Tewes, Laacke and others have shown that ocelots prefer this habitat type in south Texas[12]. Plant species that are found exclusively in or near the *Loma*/Coastal Brushland community include Berlandier's Fiddlewood, Coral Bean

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[7]Cabeza de Vaca, A. 1542. *La Relacion y Comentarios del Goubeernador Aluar Nunez Cabeza de Vaca de lo Acaescido en las Dos Jornadas que Hizo a las Indias*. Translated and edited by Cyclone Covey, in Adventures in the Unknown Interior of America. University of New Mexico Prress. Albuquerque, NM. 160 pp.

[8]Berlandier, L. 1857. *Espedicion Cientifica del General Teran a Tejas*. Boletin de las Sociedad Mexicana de Geografia y Estadistica 5:125-133.

[9]Inglis, J. 1961. A History of Vegetation of the Rio Grande Plain. Texas Parks and Wildlife Department, Austin, Tx. 122 pp.

[10]Clover, E.U. 1937. Vegetational Survey of the Lower Rio Grande Valley, Texas. Madrono 4(2) 41-66 and 4 (3) 77-100.

[11]Johnston, M.C. 1963. Past and Present Grasslands of Southern Texas and Northeastern Mexico. Ecology 44(3), 456-466.

[12]U.S. Fish and Wildlife Service. 1990. Listed Cats of Texas and Arizona Recovery Plan (With Emphasis on the Ocelot). Endangered Species Office, Albuquerque, NM.

(*Erythrina herbacea*), Thyrsus Dalea (*Dalea scandens*), the rare *Lila de los Llanos* (*Echeandiachandleri*) and the endemic grass Padre Island Dropseed (*Sporobolus tharpii*).

Silt deposited by the Rio Grande has built up higher ground in the vicinity of its channel. This has formed a slight ridge of high ground which is not flooded by seawater during hurricanes, which extends the potential range of the riparian forest to within about 10 miles upstream from Boca Chica. Although this peninsula of arable land has been cleared for cultivation, Berlandier observed mesquite and prickly pear groves there in 1829. The Sabal Palm Forest of the South most area, south and east of Brownsville, has many affinities with the vegetation of Soto la Marina, Tamaulipas, and corresponds to the description by Miranda and Hernández X of the *Selva Baja Espinosa Subperennifolio* (Low Semi-Deciduous Tropical Thorn-Forest) community.[13] The Sabal Palm Forest is an adaptation of the riparian forest to the relatively humid, moderate climate near the Gulf coast. Texas sabal palm also occurs naturally at low densities in the riparian forest as far upstream as Mier, Tamaulipas. The Audubon Sabal Palm Sanctuary protects a 40-acre remnant of this riparian forest, within which also thrive such notable plant species as David's Milkberry, Runyon's Water-Willow (*Justicia runyonii*), Vasey's Adelia (*Adelia vaseyi*), Brush Holly (*Xylosma flexuosa*), Twining Tournefortia (*Tournefortia volubilis*) and Crucillo (Randia rhagocarpa).

According to Berlandier, the riparian forest reached its greatest development on the floodplain between Matamoros and Reynosa, and was more extensive on the north side of the river. Above Reynosa, the riparian forest gradually narrowed between ridges of higher ground; above Peñitas, it was dominated by honey mesquite and prickly pear. Fleetwood described the modern riparian forest vegetation at Santa Ana NWR.[14] Within the riparian forest, the low moist soil near water supports stands of Rio Grande ash and sugar hackberry reaching 15 to 20 m in height. This community is also referred to as flood forest, in areas where temporary shallow flooding occurs; Montezuma baldcypress and Mexican buttonbush (*Cephalanthus salicifolius*), both rare peripheral species, occur here at the water's edge. Slight ridges within the riparian forest are dominated by cedar elm, Texas ebony, anacua, brasil, Texas persimmon (*Diospyros texana*), coma and *jaboncillo* (*Sapindus saponaria*), often draped with Spanish moss and ball moss (*Tillandsia usneoides* and *T. recurvata*). Here one may find Bailey's ball moss (*T. bailleyi*), a rare epiphytic bromeliad, clinging to rough-barked limbs of Texas ebony and cedar elm trees. Runyon's water-willow, another rare species, and tepozán (*Buddleja sessiliflora*), may occur under canopy gaps. Although the shrub layer is conspicuously sparse, hachinal (*Heimia salicifolia*), chilipiquín (*Capsicum annuum*), eupatorium (*Eupatorium odoratum, E. incarnatum* and *E. azureum*), manzanita (*Malpighia glabra*), southern dewberry (*Rubus trivialis*) and *Wissadula amplissima* are adapted to the dense shade of the riparian

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[13] Martinez y Ojada, E., and F. Gonzalez M. 1977. *Vegetacion del Sudeste de Tamaulipas*, Texico. Biotica 2(2): 1-45; and Miranda, F. And E. Harnandez X. 1963 *Los Tipos de Vegetacion de Mexico y su Clasificacion*. Bol. Soc. Bot. Mexico 28:29-179.

[14] Fleetwood, R. 1973. Plants of Santa Ana National Wildlife Refuge, Hidalgo County, Texas. U.S. Fish and Wildlife Service. Alamo, Texas. 55 pp.

forest; Turk's cap (*Malvaviscus arboreus*) is restricted mainly to Cameron County. An abundant ground cover of such herbaceous plants as pigeon-berry (*Rivina humilis*), bunch cut-grass (*Leersia monandra*), garlic guinea-hen bush (*Petiveria alliaceae*), Texas nightshade (*Solanum triquetrum*), amantillo (*Abutilon trisulcatum*), malva loca (*Malvastrum americanum*), and Runyon's ruellia (*Ruellia runyonii*) thrives in this moist, protected community. Here also the lianas flourish, represented by Texas virgin's bower (*Clematis drummondii*), snail-seed (*Cocculus diversifolia*), vine mimosa (*Mimosa malacophyla*), pepper-vine (*Ampelopsis arborea*), ivy treebine (*Cissus incisa*), *Serjania brachycarpa*, Mexican urvillea (*Urvillea ulmacea*), balloon-vine (*Cardiospermum halicacabum*) and alamo vine (*Ipomoea sinuata*) among others.

As elsewhere in the delta, minor changes in elevation cause noticeable differences in vegetation. Before the delta was cleared and leveled for agriculture, and before flood control dams and levees were built, the Rio Grande regularly flooded once or twice a year. Numerous distributaries, such as the Arroyo Colorado, Resaca del Rancho Viejo and Arroyo del Tigre, flowed out to the Gulf of Mexico during high water. Old river channels or oxbow sloughs, known locally as *resacas* or *esteros*, also filled during flood stages, becoming stagnant, slowly drying pools and mud flats during dry periods. The word "*resaca*" itself, which in Spanish does not refer to rivers, may have resulted from the anglicization of *río seco* (dry river), according to Elivaldo Sandoval, Sr. (personal communication). This vast network of channels allowed floodwaters to spread out over the entire delta, creating extensive wetland habitat for ducks, herons and other waterfowl, and amphibians such as the Rio Grande lesser siren and the black-spotted newt. Where strong currents did not periodically scour out the channels, *tulares* - marshes of cattails and reeds - provided nesting habitat for birds such as rails, soras and bitterns. Woody species such as black willow and coyote willow (*Salix exigua*), *Jara* (*Baccharis neglecta* and *B. salicifolia*), rattlebox (*Sesbania drummondii*), retama, huisache (*Acacia farnesiana*), tepeguaje, black mimosa (*Mimosa pigra*) and occasionally, Montezuma baldcypress encroached on those wetlands which were only occasionally flooded.

"Islands" and ridges of higher ground within the flood plain, as well as the higher river terraces in other parts of the delta, support the *mesquital-chaparral* and *chaparral* formations described by Clover. The Mid-Delta Thorn-Forest community correspond to Clover's *mesquital-chaparral*. In strict ecological terms, the word *chaparral* applies to communites of dwarfed oaks[10], which do not occur here; the Spanish word *matorral* is more accurate. The *mesquital-matorral* (mesquite-brushland) has a more or less discontinuous canopy dominated by honey mesquite, intermingled with a complex brush understory. Co-dominants may include sugar hackberry, anacahuita, coma, anacua, Wright's acacia (*Acacia wrightii*), tenaza (*Pithecellobium pallens*) and Texas ebony. The characteristic brush species include granjeno, lotebush, elbow bush, prickly pear, Berlandier's wolfberry (*Lycium berlandieri*), *Eupatorium* spp., Texas persimmon, whitebrush (*Aloysia gratissima*), southwestern bernardia (*Bernardia myricaefolia*), Texas lantana (*Lantana horrida*), *Croton* spp., tasajillo (*Opuntia leptocaulis*), guayacán (*Guaiacum angustifolium*), chilipiquín, colima, coyotillo (*Karwinskia humboldtiana*), chapotillo (*Amyris texana*), brasil, snake-eyes (*Phaulothamnus spinescens*), and manzanita.

Other species restricted to the more humid, eastern part of the delta include mescal bean (*Sophora secundiflora*), devil's claw (*Pisonia aculeata*), *Capparis incana*, brush holly, salvadora (*Solanum erianthum*) and barbed-wire cactus. Locally rare or peripheral species, such as Vasey's Adelia, crucillo, and Sierra Madre torchwood (*Amyris madrensis*) occur as isolated remnant populations. Only 15 Limoncillo trees (*Esenbeckia runyonii*) still occur in Texas, along the banks of the Resaca del Rancho Viejo. *Ayenia limitaris*, a Federally-listed endangered species, is represented by a single population of 28 individual plants in eastern Hidalgo County.

Today, remnants of the mesquite-brushland community extend far to the north, gradually replaced by low brush on drier or sloping land. No one can be exactly sure how the land appeared before cattle were brought to the delta. In Clover's analysis, the floodplain between the river and the Mission Ridge was always dominated by dense brushland and riparian forest; as one traveled north of the Mission Ridge into the drier, sandier soils of northern Hidalgo county, the *mesquital-chaparral* gradually thinned to *mesquital-nopalera* (mesquite-prickly pear), *mesquital-zacatal* (mesquite prairie or savanna) and finally the *zacatal* or prairie of the "Wild Horse Desert". Johnston's study of remnant grasslands attributes the replacement of prairie by mesquite-dominated woodlands to control of wildfires, which would otherwise have limited colonization and growth of mesquite. Johnston also provides evidence that these prairies were never completely free of mesquite, but that frequent fires maintained mesquite plants in a stunted form. Archer, et. al. gave another compelling explanation for the spread of mesquite-dominated woodlands into grasslands:[15]

> *"With the introduction of cattle, sheep and horses, all effective vectors of mesquite seed dispersal, Prosopis abundance and stature would subsequently have increased in upland grasslands. Livestock appear to be an especially effective vector of Prosopis seed dispersal in that they transport large numbers of seeds away from parent trees where host-specific seed and seedling predators may exist, scarify them and deposit them in a nutrient-rich media (dung) in areas where herbaceous interference and the probability of fire have been reduced by grazing. As mesquite developed on grazed sites, the structural complexity of the single-stratum grasslands would have increased, attracting avifauna that frequent wooded habitats. Mesquite saplings and trees in grasslands may have then become recruitment foci for the bird-disseminated seeds of woody plants occupying other habitats."*

It seems very likely that the combined forces of cattle and fire suppression have helped extend the range of the mesquite-brushland northward into areas once dominated by grasses and herbaceous plants. Between the prairie and the dense brushland of the floodplain, there must have been a transition zone of savanna, in which brush mottes were interspersed in grassland.

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[15] Archer, S., C. Scifres, C. Bassham and R. Maggio. 1988. Autogenic Succession in a Subtropical Savanna: Conversion of Grassland to Thorn Woodland. Ecological Monographs 58(2), pp. 111-127.

The woody plants would have occupied moist spots where there was some protection from hot fires.

Lonard lists 131 species of native grasses, including eight endemic species, and 52 species of exotic grasses in the lower Rio Grande valley.[16] Nevertheless, the overwhelming majority of grass plants we observe in the valley consists of just seven exotic species - Bermudagrass (*Cynodon dactylon*), Buffelgrass (*Cenchrus ciliaris*), Guineagrass (*Panicum maximum*), Johnsongrass (*Sorghum halapense*), Angleton Bluestem (*Dicanthium aristatum*), King Ranch Bluestem (*Dicanthium annulatum*) and Kleberg Bluestem (*Bothriochloa ischaemum* var. *songarica*). Due to the expansion of brushlands and competition from aggresive exotic grasses, many native grass species have become very scarce. Although it is impossible to say exactly where prairie, savanna and brushland communities existed at a particular time in the past, it seems certain that some forms of grassland and savanna predominated in the northern portions of the Río Grande delta. This prairie-brushland ecotone includes the Woodland Potholes and Basins community, characterized by gently sloping fine sandy-loam soils interspersed with numerous seasonal wetlands and playa lakes. Three unusual saline lakes occur here: La Sal Blanca (East Lake), La Sal Vieja and the historically significant La Sal del Rey.

The transition between the floodplain and the uplands of the Rio Grande plains is the Bordas Escarpment (Goliad Formation), where deposits of caleche, gravel, gypsum, sandstone and other soil materials are exposed. Erosion of the uplands has produced a band of steep hills paralleling the Rio Grande, cut by numerous arroyos, where topographic relief is up to 150 feet. Here, the wide range of slope, soil types exposed, drainage, permeability and exposure produce a multitude of unique micro-communities of plants adapted to those conditions. In the transition from deep, level floodplain soil to increasingly well-drained, exposed sites, the woody vegetation becomes shorter in stature and more widely spaced. Honey mesquite is absent or greatly reduced in very dry sites, especially where the rooting zone is impeded by impermeable layers, such as indurated caleche. Many of the woody species found in the brush understory of the mesquite-brushland also occur here in a more drought-adapted form. For example, coma, guayacan and Texas persimmon, which become small trees with predominant main trunks in riparian forests, occur also in arid uplands as rounded shrubs with greatly reduced, thicker leaves. Additional woody species of these arid uplands, corresponding to the Upland Thorn Scrub and Barretal Communities, include desert yaupon (*Schaefferia cuneifolia*), guajillo, Gregg's acacia (*Acacia greggii*), calderona (*Krameria ramosissima*), woolly bee-brush (*Aloysia macrostachya*), chomonque (*Gochnatia hypoleuca*), wild oregano (*Lippia graveolens*), blue sage (*Salvia ballotaeflora*), skeleton-leaf golden-eye (*Viguiera stenoloba*), Mexican fiddlewood (*Citharexylum brachyanthum - spathulatum*), anacahuita, palo verde, Texas baby-bonnets (*Coursetia axillaris*), yucca, flor de San Juan (*Macrosiphonia macrosiphon*), shorthorn zexmenia (*Zexmenia brevifolia*), canatilla (*Ephedra antisyphillitica*), Torrey croton (*Croton

[16] Lonard, R. 1993. Guide to the Grasses of the Lower Rio Grande Valley, Texas. The University of Texas Press. Edinburg, Texas. 240 pp.

incanus), leather stem (*Jatropha dioica*), allthorn (*Koeberlinia spinosa*), kidneywood (*Eysenhardtia texana*), heart-leaf hibiscus (*Hibiscus cardiophyllus*), Texas colubrina (*Colubrina texensis*), knife-leaf condalia (*Condalia spathulata*), cenizo, amargosa (*Castela texana*), wooly pyramid-bush (*Melochia tomentosa*), and desert lantana (*Lantana macropoda*). The barreta, although a very common tree in the sierras around Monterrey, occurs only in shrubby form on caleche hilltops in this region. These are among the most arid sites, and the specialized community adapted to these extreme conditions is the Barretal.

Rainwater runs off very quickly from many upland areas, due to the sloping topography, impeded percolation and relatively sparse vegetation. This water collects in the arroyos and the headers of arroyos, known in Spanish as "*derramaderos*". The deep deposits of alluvial soil and greater moisture availability provide for a mesic community composed of many plant species found in the Riparian Forest and the mesquite-brushland. These extensions of mesic forest and brush through the arid uplands are known as the Ramadero Community.

On arid upland sites, the absence of a dense overstory allows a high diversity of sun-loving herbaceous plants and sub-shrubs to thrive. If grazing has not been too severe, many native grass species are interspersed among the low shrubs. The dry hilltops and slopes also support a variety of cactus species, which occur only where there is less competition from grasses and other fast-growing plants. Most of the twenty-five species of cacti known from the area of ecological concern occur on these sites.

Many of the unique plant communities of the Bordas Escarpment and surrounding uplands have been destroyed by surface-mining of caleche, sand and gravel, housing developments, highways and root-plowing. Several species which are endemic to unique soil types found along the escarpment or adjacent uplands have become very rare and several are listed endangered species. Runyon's huaco (*Manfreda longiflora*) and Chihuahuan balloon-vine (*Cardiospermum dissectum*) occur sporadically in caleche soils. The ashy dogweed (*Thymophila tephroleuca*), once known from a site north of Rio Grande City, is now restricted to two sites in Zapata County with deep, sandy soil. Walker's manioc (*Manihot walkerae*), occurs exclusively in calcareous sands shallowly overlying indurated caleche. Johnston's frankenia is found on saline or gypsum soils of the Maverick series. The star cactus (*Astrophytum asterius*) is currently known from only one U.S. site north of Rio Grande City, which also is saline and gypsaeous. These last four are listed endangered species. Zapata bladderpod (*Lesquerella thamnophila*) has been found on several sites with sandy or caleche soil; this species is currently "Proposed Endangered".

The same basic community types that occurred on the north side of the Rio Grande, also occurred south of the river. Vast amounts of mesquite-brushland in the broad delta in Tamaulipas were cleared during the 1970s in order to create impoverished cropland. As on the U.S. side, much of the coastal zone is fairly intact; the high salinity and potential for flooding during hurricanes has discouraged development. The Bordas Escarpment, defining the boundaries of the delta, crosses the river just upstream from Reynosa and runs in a southeasterly direction toward San Fernando. Very little floodplain habitat remains in the Mexican side of the delta, but extensive upland habitat still exists between the Bordas Escarpment and the foothills of the Sierra Madre Oriental. Vast amounts of diverse, high-quality habitat also exists in this mountain range. The Rio Alamo, which joins the Rio Grande near Mier, Tamaulipas, is a potential wildlife corridor route linking the Rio Grande corridor with the Sierra de los Picachos, the nearest segment of the Sierra Madre Oriental.

3.3 Wildlife

Tamaulipan brush land provides important feeding, nesting, and cover habitats for many species. Brush clearing and other human activities thus have profound impacts on a variety of vertebrates and invertebrates in LRGV. Diversity of habitat types in LRGV results in a diverse vertebrate fauna, including species of subtropical, southwestern desert, prairie, coastal marshland, eastern forest, and marine affinities.[17] About 700 vertebrate species have been found within the LRGV (four County area). Of those species in need of special attention, the Service has continued to use appropriate management strategies to provide protection in accordance with policy and law including the Endangered Species Act. A number of vertebrate species found in LRGV are not found in any other region of the United States. The endangered ocelot and jaguarundi use extremely dense, impenetrable brush thickets for traveling and breeding.[18] Remnant brush tracts of this type are found only in south Texas. Ocelots also are found in oak savannah habitat types in south Texas, which consist of open grassland, scattered groves, or "mottes," of live oak *(Quercus virginiana)*, and a mid-story of live oak saplings and various thorn forest species. The ocelot once roamed eastern, central, and southern portions of Texas, but today it exists mainly in south Texas brush land. Jaguarundi habitat in south Texas is poorly known but may be similar to ocelot habitat.

There are numerous species found in Mexico and Central America whose ranges reach their northern most limit in the LRGV. Included among these are: brown jay (*Cyanocorax morio*), ringed kingfisher (*Ceryle torquata*), red-billed pigeon (*Columba flavirostris*), Chachalaca (*Ortalis vetula*), speckled racer (*Drymobius margaritiferus*), and Mexican treefrog (*Smilisca baudinii*).

The white-winged dove (*Zenaida asiatica*) continues to be an important game bird in the LRGV. Whitewings were so abundant in the LRGV that they were market hunted in the late 1800's. The population slowly declined as more and more brushland nesting habitat was cleared for agriculture. By 1940 the fall population was estimated at 500,000 birds and 200,000 by 1950.

[17] International Boundary and Water Commission, 1982. Environmental assessment of the proposed increased diversion of 500 cfs from Main Floodway to Arroyo Colorado Floodway. Lower Rio Grande Flood Control Project, Texas. El Paso, TX. 88pp.

[18] Ibid Jahrsdoerfer et al, 1988 citing Goodwyn, 1970: Davis 1974; Tewes and Everett, 1982, and Rappole, 1988.

More and more citrus was being planted in the LRGV and the birds began move into the groves to nest and populations again began to increase. Citrus is subject to freeze however and periodic losses of citrus habitat caused whitewing declines in the years following severe winters. Whitewings surprised the experts in the 1980's by beginning a major population buildup in areas north of the LRGV, particularly in cities such as San Antonio and Austin. By the mid 1990's there were more whitewings nesting in these northern sites than in the LRGV. It is hoped that as reforested areas of the LRGV NWR mature into suitable nesting habitat the whitewing population will increase significantly.

Habitats in LRGV also support a unique invertebrate fauna and many of these species also reach their northern limits of distribution in south Texas. At least 246 species of butterflies have been identified at Santa Ana NWR. Invertebrate populations have received little research attention, thus their status is largely unknown. However, habitat alterations likely have been detrimental to the invertebrate fauna of LRGV.

3.4 Climate

The climate of the area is semi-arid and subtropical. Mean annual rainfall in the eastern LRGV (Cameron Co.) is 25.4 inches with a mean July high temperature of 93 degrees Fahrenheit and a mean January low temperature of 51 degrees Fahrenheit. The western LRGV (Starr Co.) has a mean annual rainfall of 20.6 inches, a mean July high of 99 degrees Fahrenheit and mean January low of 44 degrees Fahrenheit. Some years are free of frost, and hard freezes are rare.[19] Tropical storms and hurricanes periodically strike the area during the summer and fall months. Storms of hurricane force may be expected at a frequency of about 1 every 10 years.[20]

3.5 Geology

The topography of the LRGV is generally flat. From a chain of hills of indurate caleche with sandstone outcrops and fossil oyster reefs in the west, known as the Bordas Escarpment (Bordas Scarp), the land slopes gently to the coast at approximately 0.4 meters per kilometer.[21] Soils in the LRGV range from dark, clayey soils in the uplands to gray, clayey, saline soils on

[19] Kingston, M. Editor. 1992-93. Texas Almanac. A.H. Belo Corporation, Dallas, Texas. 656p.

[20] Morton, R.A., O.H. Pilkey, Jr., O.H. Pilkey, Sr., and W.J. Neal. 1983. Living with the Texas shore. Duke University Press, Durham, North Caroline. 190pp.

[21] Lonard, R.I. 1985. Natural communities of the South Texas Plains. Proceedings of the Texas Academy of Science, Conservation Committee on Natural Communities of Texas. University of Texas, Dallas. 12 pp.

the coastal plain. Riparian areas have gray, silty loams or clays. Generally, soils away from the river tend to be fine, sandy loams with moderate to slow permeability and slow runoff. [22]

The changing course of the Rio Grande caused changes in the vegetation. Alluvial soils were deposited in places and carried away in others. Floods would fill up resacas, killing some plants and permitting the growth of other plant species. Gulf storms destroyed vegetation by wind-action or by blowing salt water inland. The filling of estuaries caused unstable conditions for plant development.

3.6 Soils

Cameron County -- Level to gently sloping, moderately permeable to very slowly permeable, saline, clay and loamy soils.

Hidalgo County -- Many of the soils in the county formed in sediments deposited by the Rio Grande. These sediments are mostly clay and sand; there are some silt deposits near the river. The Gulf of Mexico may have been the origin of the sandy soils in the northern part of the county. The nearly level soils are often seasonally wet. Irrigation water from the Rio Grande has been a source of toxic salts to the soils

Starr County -- Rainfall, temperature, humidity, and wind have been important in the development of soils in this county. Starr County is more hilly than other areas of the LRGV. Soils range from deep alluvial soils along the river to formations exposed on the Bordas Escarpment such as the Jemez-Quemado (caleche-gravel), Randado-Cuevitas (reddish sandy loam), and the Maverick Series (saline gypsum deposits). These soil types support several rare plant communities.

Willacy County -- Willacy County is split between the aeolian sand plain in the northwest, saline clays in the Coastal Plain, and deep delta soils make up much of the remaining lands. Hypersaline lakes such as La Sal Vieja and La Sal del Rey were the most important geographical spots in the LRGV for centuries. Native Americans and early settlers came to the great lake beds to gather salt for their diets, for tanning animal hides, and for trading. Salt brine continues to be extracted from La Sal del Rey.

3.7 Water Development, Flood Control, and International Boundary Stabilization

Water development in the LRGV has centered on flood control and providing irrigation water for agriculture. Since the turn of the century, extensive farming and irrigation development

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[22] Thompson, C.M., R.R. Sanders, and D. Williams. 1972. Soil survey of Starr County, Texas. Soil Conserv. Serv., Washington, D.C. 62 pp. Williams, D., C.M. Thompson, and J.L. Jacobs. 1977 Soil survey of Cameron County, Texas. Soil Conservation Service, Washington, D.C. 92 pp. Turner, A.J. 1982. Soil survey of Willacy County, Texas. Soil Conserv. Serv., Washington, D.C. 137 pp.

have occurred in the rich, fertile delta of the Rio Grande. Several private irrigation and/or drainage districts have been established in the LRGV to provide either drainage or irrigation service to the agriculture industry and municipalities.[23]

The Rio Grande overflowed 23 times between 1900 and 1939 in Cameron and Hidalgo Counties. These counties constructed flood control levees in the most flood prone areas to protect farmlands and urban developments. In 1944, a Water Treaty was signed between the United States and Mexico, distributing between the two countries the waters of the Rio Grande. The U.S. Section of the International Boundary and Water Commission (IBWC) took over the county maintained flood levees in the United States and with the Mexican Section of the IBWC established the Lower Rio Grande Valley Flood Control Project (LRGVFCP). The 1944 Water Treaty also provided for the development, construction and operation by the IBWC of a number of water use and control projects on behalf of the two countries, including the construction of off-river interior floodways within both countries, the building of levees along both sides of the Rio Grande to form a river floodway, and the construction of two diversion dams, Anzalduas and Retamal, to permit diversion of Rio Grande floodwaters into the interior floodways. The IBWC defines its role as follows:

> *The United States portion of the project is operated to divert and convey river flood waters from the Rio Grande to the Gulf of Mexico through river and interior floodway systems and thus limit flood flows in the lower river reaches (i.e. Brownsville, Texas and Matamoros, Tamaulipas) to safe levels in conformance with international agreements. On the United States side of the Rio Grande, the works consist of about 102 miles of levees along the Rio Grande and about 168 miles of levees flanking an interior floodway system including the Arroyo Colorado. The Main Floodway, North Floodway, and the Arroyo Colorado are the main features of the U.S. Section's interior floodway system. At a point about two miles southwest of Mercedes, the Main Floodway merges into the Arroyo Colorado, a deeply notched distributary of the Rio Grande which extends to the Laguna Madre. The North Floodway also branches from the Main Floodway at this location southwest of Mercedes. The North Floodway was developed in the same manner as the Main Floodway along other distributaries of the Rio Grande and extends across northwestern Cameron County and southeastern Willacy County to the Laguna Madre.*[24]

As part of the project, Anzalduas Diversion Dam was constructed from 1956 to 1960 on the Rio Grande to assure the necessary diversion of the United States share of river flood waters into the United States interior floodway system. The dam also enables Mexico to divert its share of the normal flows into Mexico's main irrigation canal. Similarly, Retamal Diversion Dam was constructed between 1971 and 1975 on the Rio Grande. Its serves the two-fold flood control purpose of enabling Mexico to divert its share of river flood waters into the Mexican floodway system and to limit flood flows at Brownsville and Matamoros to the safe capacity of

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[23] Ramirez, P., Jr., 1986. Water development projects in the Rio Grande and their relationships to the Santa Ana and Rio Grande Valley National Wildlife Refuges. Unpublished Report, U.S.F.W.S, Ecological Services, Corpus Christi, TX. 47 pp.

[24] IBWC, U.S. Section. May 1991. Biological Assessment on the Lower Rio Grande Flood Control Project in Hidalgo, Cameron and Willacy Counties, Texas.

the Rio Grande. Anzalduas and Retamal Diversion Dams are operated jointly by the United States and Mexico for flood control.

The Treaty 1944 between the two countries provided for the construction of flood control structures on the Rio Grande. The lowermost of the major dams, Falcon Dam, is located between Laredo and Rio Grande City in Starr County about 275 river miles upstream of the mouth of the river. Construction began in 1950 and the dam was completed in 1954.

The IBWC's February 1993 Revised Biological Assessment on the Lower Rio Grande Flood Control Project Vegetation Clearing Activities in Hidalgo, Cameron, and Willacy Counties, Texas describes two Commission Minutes as follows:

> *The first specific United States/Mexico agreement under the 1944 Water Treaty is the IBWC Minute No. 238. Specifically, the U.S. and Mexico must safely pass through this system, a design flood flow of 250,000 cfs measured at Rio Grande City, Texas. Of that amount, the United States is required to divert at Anzalduas Dam, upstream of Hidalgo, Texas, into its Off-River Floodway System 105,000 cfs, such that the design flood flow for the Rio Grande floodway below Anzalduas Dam of 130,000 cfs is reduced to 125,000 cfs to a point where Mexico diverts 105,000 cfs into its Off-River Floodway System at Retamal Dam, south of Donna, Texas. In this manner, the design flood flow in the Rio Grande floodway below Retamal Dam is reduced to 20,000 cfs.*
>
> *The second specific agreement is in IBWC Minute No. 212 regarding an annual vegetation clearing program along the banks of the Rio Grande for a distance of 34.5 miles upstream and downstream of Brownsville/Matamoros, between Mile 62.5 and Mile 28. Vegetation clearing activities begin at the water's edge landwards for a small distance. This consists of mowing to ground level, including removal of trees and underbrush, but not stacking and burning. Cleaning and removal of under brush, which can be performed by hand, is performed approximately every five years on the high banks as needed to prevent debris accumulation in the river channel which would in turn reduce the carrying capacity. This vegetation clearing permits the safe passage of the design flood flow of 20,000 cfs in this reach of the River Floodway.*[25]

In addition, under the 1970 Boundary Treaty, the IBWC maintains the Rio Grande as the international boundary between the United States and Mexico by protecting the river bank from erosion and preventing the shifting of the river from its present channel. The IBWC, on behalf of the U.S. and Mexico, may take a number of measures to preserve the Rio Grande channel as the international boundary. These measure include vegetation clearing, channel excavation, bank protection and channel rectification. Furthermore, the IBWC may approve or disapprove the construction of works in the river channel or adjacent lands.

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[25] IBWC, U.S. Section. February 1993. Revised Biological Assessment on the Lower Rio Grande Flood Control Project Vegetation Clearing Activities in Hidalgo, Cameron, and Willacy Counties, Texas.

3.7. LRGV and the Los Caminos Del Rio Heritage Corridor

The Texas Historical Commission (THC) initiated the Los Caminos del Rio Heritage Project in 1989. The purpose of its establishment was to promote the linkage of cultural and natural resources of the corridor region and the eventual development of a coordinated "heritage trail" that would attract visitors. The ultimate desired outcome of this endeavor is the preservation of a unique heritage shared by the United States and northern Mexico along the Lower Rio Grande. A framework of partnerships form the basis for the project and participants include regional, state and national organizations and governments, local citizens and businesses.

All of the LRGV and Santa Ana refuge lands are included in the heritage corridor and two of the significant historic sites within the heritage corridor are actually on Refuge lands. As part of the heritage corridor partnership effort the Palmito Ranch Battlefield on LRGV tracts near Brownsville were nominated to be on the National Register of Historic Places, and the Old River Pumphouse on LRGV refuge lands near Hidalgo was nominated for a National Historic Landmark designation.

3.8 LRGV Socio-economic Features

The agricultural industry, mainly farming, has been a dominant element of the LRGV socio-economic picture since the early 1920's. As this industry grew, both in the United States and in Mexico, the population of the LRGV and associated infrastructure (housing, industry, malls, etc...) has expanded tremendously. Subsequently, urbanization in the LRGV has driven economic growth for the past few decades. More recently, trade and manufacturing have increased steadily and are surpassing the once dominant agricultural industry as one of the leading economic industries. The "maquiladora" (twin plant) industry, where U.S. companies establish manufacturing plants in Mexico and then retail the products in the U.S., have increased and are likely to continue this upward development in anticipation of NAFTA.

Population Growth -- The Lower Rio Grande Valley is one of the fastest growing areas in the United States, with a population on both sides of the border of approximately two million people. Between the years 1975 and 1995 the Cameron, Hidalgo and Willacy Counties will grow an average of 29.4 percent. Populations in Cameron County have grown to surpass the projected 240,000 for 1995. The total Valley tourist population has surpassed the 1995 projected 150,000. This growth is equaled by bordering cities in Mexico whose combined growth with that of the U.S. in the LGRV is projected to grow to 4.3 million by the year 2020.

Income Trends -- Growth in the LRGV can be linked to the development of the maquiladora industry in Mexico, and is expected to double between 1990 and 2010. Yet, close to half of the population on the U.S. side has an annual income below the poverty level. The LRGV is considered to be one of the most impoverished regions in the United States.

Economic Development Pressures -- According to 1983 figures, economic development within the ecosystem can be divided into five segments : (1) Trade (2) Manufacturing (3) Agriculture (4) Oil and Gas Production, and (5) Tourism.

The tourism industry continues to grow each year. Many "Winter Texans" come to the LRGV as early as September and remain until April, when the LRGV population increases by 100,000-125,000 (U.S. Census Bureau 1990). The LRGV is considered a gateway to Mexico for those traveling south and to the U.S. for individuals traveling north. Tourism contributes $500 million per year to the total economy (Rio Grande Valley Chamber of Commerce 1992).

Trade with Mexico increased 250% since 1983 and is projected to increase 400% by the year 2020. By the end of 1993, growth in U.S./Mexico trade had already occurred without a North American Free Trade Agreement (NAFTA) in place. Tripled volume of trade has been the result of only a few trade restrictions removed. Exports to Mexico rose from $12 billion in 1986 to a nearly $40 billion in 1993. According to International Trade Commission (ITC) studies for the US Senate Finance Committee, international trade with Mexico will increase markedly as a result of the passage of NAFTA.

3.9 Refuge Staffing Needs

The diversity and complexity of land management programs on Service managed lands in the LRGV ecosystem have increased as lands continue to be added to the project. Thus, it is anticipated that growing habitat enhancement and maintenance requirements will continue to place added funding and operational staffing pressures on the refuge. Water management for example, will continue to expand while some activities will gradually be reduced as revegetation efforts succeed. However, even a minimum degree of progress in revegetation and farming efforts will be contingent upon the ability of the refuge to staff and fund these activities adequately.

The staffing chart on the following page reflects currently allocated positions throughout the planning period including proposed increases in grade levels and conversions of positions from term and part time positions to full time permanent positions. As additional lands are acquired beyond the five year planning horizon, additional staff will be necessary.

LOWER RIO GRANDE VALLEY NWR/ SANTA ANA NWR STAFFING CHART 1997-2001

Project Leader GS-13
GS-14 proposed

Secretary GS-6

Deputy Project Leader
GS-12
GS-13 Proposed

Public Outreach Specialist
GS 9-11

Supervisor ROS*/ Santa Ana NWR/

- Refuge Officer, GS-9
- Refuge Officer, GS-9 (proposed)
- Refuge Officer, GS-9 (proposed)
- Refuge Operations Spec. GS-5/7/9
- Refuge Operations Spec. GS-5/7/9
- Refuge Operations Spec. GS-5/7/9
- Refuge Operations Spec. Trainee, GS-5/7 (proposed)
- Engineering Equip. Operator, WG-8 term (Proposed permanent full time)
- Tractor Operator, WG-5 Term (proposed Permanent full time
- Office Assistant, GS-6
- Maintenance Worker, WG-8
- Park Ranger, Habitat Restoration Spec., GS-9

Supervisory ROS*/ LRGV NWR/ GS-12/]
GS-13 Proposed

- Refuge Operations Spec. GS-9
- Biological Tech. GS-5/6/7
- Maint. Worker WG-5
- Tractor Operator WG-6
- Office Clerk GS-5
- Outdoor Rec. Planner GS-5/7 (GS-9 proposed)
- Park Ranger GS-4, part Time (permanent full Time proposed)
- Park Ranger GS-4, part Time (permanent full Time proposed)
- Outdoor Rec. Planner GS-5/7

Plant Ecologist GS-11

- Forestry Tech., GS-6
- Forestry Tech, GS-6 term

Wildlife Biologist GS-12

- Wildlife Biologist GS-7/9/11
- Biological Tech., GS-5/7
- GIS/ADP Spec., GS-9/11 (Proposed)

Wildlife Biologist / Fire Mgmt. Officer,
GS-9/11

- Fire Control Officer GS-9/10
- Forestry Tech., GS-3/4/5/6 crew boss
- Forestry Tech, GS-3/4/5
- Forestry Tech. GS-3/4/5
- Forestry Tech. GS-3/4/5
- Dispatcher, GS-5
- Forestry Tech. GS-3/4 (proposed)
- Forestry Tech. GS/3/4 (proposed)
- Tractor Operator, WG-6/8 (proposed)

4.0 Legal, Policy, and Administrative Guidelines, and Other Special Considerations

This Section outlines current legal, administrative, and policy guidelines for the management of national wildlife refuges. It begins with the more general considerations such as laws and executive orders for the Service, and moves toward those guidelines that apply specifically to the Lower Rio Grande Valley NWR and Santa Ana NWR.

This unit also includes sections dealing with specially designated sites such as historical landmarks and archaeological sites, all of which carry with them specific direction by law and/or policy. In addition, consideration is given to guidance prompted by other formal and informal natural resource planning and research efforts.

All the legal, administrative, policy, and planning guidelines provide the framework within which management activities are proposed and developed. This guidance also provides the framework for the enhancement of cooperation between the Lower Rio Grande Valley and Santa Ana NWRs and other surrounding jurisdictions in the ecosystem, including the government of Mexico.

4.1 Legal Mandates

Administration of the refuges takes into account a myriad of bills passed by the United States Congress and signed into law by the President of the United States. These statutes are considered to be the law of the land as are executive orders promulgated by the President. The following is a list of most of the pertinent statutes establishing legal parameters and policy direction to the National Wildlife Refuge System. Included are those statutes and mandates pertaining to the management of the Lower Rio Grande Valley and Santa Ana NWRs.

For those laws that provide special guidance and have strong implications relevant to the Service or Lower Rio Grande Valley and Santa Ana NWRs, legal summaries are offered below. Many of the summaries have been taken from *The Evolution of National Wildlife Law* by Michael J. Bean.[26] For the bulk of applicable laws and other mandates, legal summaries are available upon request.

Summary of Congressional Acts, Treaties, and other Legal Acts that Relate to Administration of the National Wildlife Refuge System:

1. Lacey Act of 1900, as amended (16 U.S.C. 701).

2. Antiquities Act of 1906 (16 U.S.C. 431).

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[26] Bean, Michael J., 1983. *The Evolution of National Wildlife Law*, Praeger Publishers, New York.

3. Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-711) and 1978 (40 Stat. 755).

4. Migratory Bird Conservation Act, (1929) as amended. (16 U.S.C. 715-715s).

5. Migratory Bird Hunting Stamp Act of 1934, (U.S.C 718-718h).

6. Fish and Wildlife Coordination Act, (1934) as amended (16 U.S.C. 661-666).

> *The Act is "the first major federal wildlife statute to employ the strategy of compelling consideration of wildlife impacts. The act authorized 'investigations to determine the effects of domestic sewage, trade wastes, and other polluting substances on wildlife, encouraged the development of a program for the maintenance of an adequate supply of wildlife on the public domain' and other federally owned lands, and called for state and federal cooperation in developing a nationwide program of wildlife conservation and rehabilitation.*[27]

7. Historic Sites Act of 1935 (16 U.S.C. 461).

> *The Act declared it a national policy to preserve historic sites and objects of national significance, including those located on refuges. It provided procedures for designation, acquisition, administration, and protection of such sites. National Historic and Natural Landmarks are designated under authority of this Act. As of January 1989, 31 national wildlife refuges contained such sites.*

8. Convention Between the United States of America and the Mexican States for the Protection of Migratory Birds and Game Mammals, (1936) (50 Sta. 1311).

9. Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere, 1940 (56 Stat. 1354).

10. Fish and Wildlife Act of 1956, as amended (16 U.S.C. 742-742j).

11. Refuge Recreation Act, as amended, (Public Law 87-714.76 Sta. 653; 16 U.S.C. 460k-4) September 28, 1962.

> *This Act authorizes the Secretary of the Interior "to administer areas of the System 'for public recreation when in his/her judgement public recreation can be an appropriate incidental or secondary use; provided, that such public recreation use shall be permitted only to the extent that it is practicable and not inconsistent with the primary objectives for which each particular area is established.' Recreational uses 'not directly related to the primary purposes and functions of the individual areas' of the System may also be permitted, but only upon an determination by the Secretary that they 'will not interfere with the primary purposes' of the refuges and that funds are available for their development, operation, and maintenance.*[28]

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[27] Ibid., pp. 181.

[28] Ibid., pp. 125-126.

12. Refuge Revenue Sharing Act of 1964, (16 U.S.C. 715s) as amended (P.L. 95-469, approved 10-17-78).

The Act provides "that the net receipt from the 'sale or other disposition of animals, timber, hay, grass, or other products of the soil, minerals, shells, sand, or gravel, from other privileges, or from leases for public accommodations or facilities in connection with the operation and management'...of areas of the National Wildlife Refuge System shall be paid into a special fund. The monies from the fund are then to be used to make payments for public schools and roads to the counties in which refuges having such revenue producing activities are located."[29]

13. Land and Water Conservation Fund Act of 1965, as amended (16 U.S.C. 460L-4 to 460L-11), and as amended through 1987.

14. National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee).

This Act, derived from sections 4 and 5 of Public Law 89-669, "consolidated 'game ranges,' 'wildlife ranges,' 'wildlife management areas,' 'waterfowl production areas,' and 'wildlife refuges,' into a single 'National Wildlife Refuge System.' It (1) placed restrictions on the transfer, exchange, or other disposal of lands within the system; (2) clarified the Secretary's authority to accept donations of money to be used for land acquisition; and (3) most importantly, authorized the Secretary, under regulations, to 'permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodations, and access whenever he determines that such uses are compatible with the major purposes for which such areas were established.'"[30]

15. National Historic Preservation Act of 1966 (16 U.S.C. 470).

Public Law 89-665 as repeatedly amended, provided for preservation of significant historical features (buildings, objects, and sites) through a grant in aid program to the States. It established a National Register of Historic Places and a program of matching grants under the existing National Trust for Historic Preservation. As of January 1989, 91 historic sites on national wildlife refuges have been placed on the National Register.

16. National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321-4347).

17. Protection and Enhancement of Environmental Quality Executive Order of 1970 (Executive Order 11514, dated March 5, 1970).

18. Environmental Education Act of 1975 (20 U.S.C. 1531-1536).

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29 Ibid., pp. 126.

30 Ibid., pp. 125.

19. Use of Off-Road Vehicles on the Public Lands Executive Order of 1972, as amended (Executive Order 11644, dated February 8, 1972, as amended by Executive Order 11989, dated May 24, 1977).

20. Endangered Species Act of 1973 (16 U.S.C. 1531-1543 87 Stat. 884) P.L. 93-205). The Endangered Species Act as amended by Public Law 97-304, The Endangered Species Act Amendments of 1982, dated February 1983.

According to Bean, the 1973 Act "builds its program of protection on three fundamental units. These include two classifications of species--those that are 'endangered' and those that are 'threatened' --and a third classification of geographic areas denominated 'critical habitats.'"[31]

The Act: (1) Authorizes the determination and listing of species as endangered and threatened, and the ranges in which such conditions exist; (2) Prohibits unauthorized taking, possession, sale, and transport of endangered species; (3) Provides authority to acquire land for the conservation of listed species, using land and water conservation funds; (4) Authorizes establishment of cooperative agreements and grants-in-aid to States that establish and maintain active and adequate programs for endangered and threatened wildlife; and, (5) Authorizes the assessment of civil and criminal penalties for violating the Act or regulations.

Section 7 of the Endangered Species Act requires Federal agencies to insure that any action authorized, funded, or carried out by them does not jeopardize the continued existence of listed species or modify their critical habitat.

21. Floodplain Management Executive Order of 1977 (Executive Order 11988, dated May 24, 1977). Wetlands Preservation Executive Order of 1977 (Executive Order 11988, dated May 24, 1977).

These executive orders require both the protection and the enhancement of wetlands and floodplain. Both were signed in May, 1977. When Federally owned wetlands or floodplain are proposed for lease or conveyance to non Federal public or private parties, both executive orders require that the agency: "(a) reference in the conveyance those uses that are restricted under Federal, State or local... regulations; and (b) attach other appropriate restrictions to the uses of such properties by the ... purchaser and any successor, ... or © withhold such properties from..." lease or disposal (E.O. 11990, 4, E.O. 11988, 3(d). In addition, each agency is required to "avoid undertaking or providing assistance" for activities located in wetlands unless (1) ... "there is no practicable alternative...", and (2)... "the proposed action includes all practicable measures to minimize harm...which may result from such use" (E.O. 11990, 2). The term "agency" is defined in both of these executive orders as having the same meaning as the term "Executive agency" which means an Executive department, a Government corporation, and an independent establishment.

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31 Ibid., pp. 331.

12. Refuge Revenue Sharing Act of 1964, (16 U.S.C. 715s) as amended (P.L. 95-469, approved 10-17-78).

The Act provides "that the net receipt from the 'sale or other disposition of animals, timber, hay, grass, or other products of the soil, minerals, shells, sand, or gravel, from other privileges, or from leases for public accommodations or facilities in connection with the operation and management'...of areas of the National Wildlife Refuge System shall be paid into a special fund. The monies from the fund are then to be used to make payments for public schools and roads to the counties in which refuges having such revenue producing activities are located."[29]

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16. National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321-4347).

17. Protection and Enhancement of Environmental Quality Executive Order of 1970 (Executive Order 11514, dated March 5, 1970).

18. Environmental Education Act of 1975 (20 U.S.C. 1531-1536).

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29 Ibid., pp. 126.

30 Ibid., pp. 125.

22. The Archaeological Resource Protection Act of 1979 (P.L. 96-95, 93 Sta. 721, dated October 1979). (16 U.S.C. 470aa - 47011).

This Act largely supplanted the resource protection provisions of the Antiquities Act for archaeological items. It established detailed requirements for issuance of permits for any excavation or removal of archaeological resources from Federal or Indian Lands. It also established civil and criminal penalties for the unauthorized excavation, removal, or damage of any such resources; for any trafficking in such resources removed from Federal or Indian land in violation of any provision of Federal law; and for interstate and foreign commerce in such resources acquired, transported, or received in violation of any State or local law. Public Law 100-588, approved November 3, 1988, (102 Stat. 2983) lowered the threshold value of artifacts triggering the felony provision of the Act from $5,000 to $500, made attempting to commit an action prohibited by the Act a violation, and required the land managing agencies to establish public awareness programs regarding the value of archaeological resources to the Nation.

23. Fish and Wildlife Conservation Act of 1980 (P.L. 96-366, dated September 29, 1980). ("Nongame Act") (16 U.S.C. 2901-2911; 94 Stat. 1322).

Approved September of 1980, this Act authorized grants for development and implementation of comprehensive State nongame fish and wildlife plans and for administration of the Act. It also required the Service to study potential mechanisms for funding these activities and report to Congress by March, 1984. According to Bean, the Act "strives to encourage comprehensive conservation planning, encompassing both nongame and other wildlife...The impetus for the enactment of this legislation was the perception that animals not ordinarily valued for sport hunting or commercial purposes receive insufficient attention and funds from state wildlife management programs."[32]

Public Law 100-653 (102 Stat. 3825), approved November 14, 1988, amended the Act to require the Service to monitor and assess nongame migratory birds, identify those likely to be candidates for endangered species listing, identify appropriate actions, and report to Congress one year from enactment. It also requires the Service to report at five year intervals on actions taken.

24. Administrative Procedures Act (5 U.S.C. 551-559, 701-706, 1305, 3105, 3344, 4301, 5362, 7521; 60 Stat. 237), as amended (P.L. 79-404, as amended).

25. Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668d; 54 Stat.), as amended.

26. Canadian United States Migratory Bird Treaty (Convention Between the United States and Great Britain (for Canada for the Protection of Migratory Birds. (39 Stat. 1702; TS 628), as amended.

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32 Ibid., pp. 227.

27. Clean Air Act (42 U.S.C. 1857-1857f; 69 Stat. 322), as amended.

28. Convention on Wetlands of International Importance Especially as Waterfowl Habitats (I.L.M. 11:963-976, September 1972).

This Convention, commonly referred to as the Ramsar Convention, was adopted in Ramsar, Iran, February 3, 1971, and opened for signature at UNESCO headquarters, July 12, 1972. On December 21, 1975, the Convention entered into force after the required signatures of seven countries were obtained. The United Senate consented to ratification of the Convention on October 9, 1986, and the President signed instruments of ratification on November 10, 1986. The Convention maintains a list of wetlands of international importance and works to encourage the wise use of all wetlands in order to preserve the ecological characteristics from which wetland values derive. The Convention is self implementing with the U.S. Fish and Wildlife Service providing U.S. secretariat responsibilities and lead for Convention implementation.

29. Cooperative Research and Training Units Act (16 U.S.C. 753a-753b, 74 Stat. 733), as amended. P.L. 86-686).

30. Federal Aid in Fish Restoration Act (16 U.S.C. 777-777k, 64 Stat. 430).

31. Federal Aid in Wildlife Restoration Act (16 U.S.C. 669-669i; 50 Stat. 917), as amended.

32. Federal Environmental Pesticide Control Act of 1972 (7 U.S.C. 136-136y; 86 Stat. 975), as amended.

33. Federal Land Policy Management Act of 1976 (43 U.S.C. 1701-1771, and other U.S.C. sections; 90 Stat. 2743). Public Law 94-579, October 1976.

34. Federal Property and Administrative Services Act of 1949 (40 U.S.C. 471-535, and other U.S.C. sections; 63 Stat. 378), as amended.

35. Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251-1265, 1281-1292, 1311-1328, 1341-1345, 1361-1376, and other U.S.C. titles; 86 Stat. 816), as amended.

36. Fish and Wildlife Improvement Act of 1978 (16 U.S.C. 7421; 92 Stat. 3110) P.L. 95-616, November 1978.

37. Flood Control Act of 1944 (16 U.S.C. 460d, 825s and various sections of title 33 and 43 U.S.C.; 58 Stat. 887), as amended and supplemented.

38. Freedom of Information Act (5 U.S.C. 552; 88 Stat. 1561).

39. Refuge Trespass Act (18 U.S.C. 41; Stat 686).

40. Transfer of Certain Real Property for Wildlife Conservation Purposes Act of May 1948, (16 U.S.C. 667b-667d; 62 Stat. 240), as amended.

41. Water Resources Planning Act (42 U.S.C., 1962-1962a-3; 79 Stat. 244), as amended.

42. Waterfowl Depredations Prevention Act (7 U.S.C. 442-445; 70Stat. 492), as amended.

43. Clean Water Act of 1972, Section 404.

Under this Act, permits are required to be obtained for discharges of dredged and fill materials into all waters, including wetlands. Implementation of the 404 program involves three other federal agencies in addition to limited state involvement. The Environmental Protection Agency (EPA), the National Marine Fisheries Service, and the Service review permit applications and provide comments and recommendations on whether permits should be issued by the Corps. EPA has veto authority over permits involving disposal sites if impacts are considered unacceptable. EPA also develops criteria for discharges and state assumption of the 404 program. Section 404 regulations were changed in 1984 due to a national lawsuit, and 404 jurisdictions now apply to tributaries of navigable waters and isolated wetlands and waters if interstate commerce is involved. With the new regulations, all washes, drainages, and tributaries of navigable waters, including ephemeral and perennial streams, are included under the 404 program in Texas.

44. The Food Security Act of 1985 (Farm Bill).

The following authorities provide the Service the means for prvention, presuppression, control and suppression of wildfire on Refuge lands.

45. Protection Act of September 20, 1922 (42 Stat. 857; 16 U.S.C. 594)

46. Economy Act of June 30, 1932 (47 Stat. 417; 31 U.S.C. 1535)

47. Taylor Grazing Act of June 28, 1934 (48 Stat. 1269; 43 U.S.C. 315)

48. National Park Service Acts as amended (67 Stat. 495; 16 U.S.C. 1b)

49. Federal Property and Administrative Service Act of 1949 (40 U.S.C. 471; et seq.)

50. Reciprocal Fire Protection Act of May 27, 1955 (69 Stat. 66; 42 U.S.C. 471; et seq.)

51. Disaster Relief Act of May 22, 1974 (88 Stat. 143; 42 U.S.C. 5121)

52. Federal Fire Prevention and Control Act of October 29, 1974 (88 Stat. 1535; 15 U.S.C. 2201)

53. Wildlfire Suppression Assistance Act of 1989 (P.L. 100-428, as amended by P.L. 101-11, April 7, 1989)

4.2 Agency-Wide Policy Directions

Fish and Wildlife Service Agency Mission -- Since the early 1900s, the Service mission and purpose has evolved, while holding on to a fundamental national commitment to threatened wildlife ranging from the endangered bison to migratory birds of all types. The earliest national wildlife refuges and preserves are examples of this. Pelican Island, the first refuge, was established in 1903 for the protection of colonial nesting birds such as the snowy egret and the endangered brown pelican. The National Bison Range was instituted for the endangered bison in 1906. Malheur National Wildlife Refuge was established in Oregon in 1908 to benefit all migratory birds with emphasis on colonial nesting species on Malheur Lake. It was not until the 1930s that the focus of refuge programs began to shift toward protection of migratory waterfowl (i.e., ducks and geese). As a result of drought conditions in the 1930s, waterfowl populations became severely depleted. The special emphasis of the Service (then called the Bureau of Wildlife and Sport Fisheries) during the next several decades was on the restoration of critically depleted migratory waterfowl populations.

The passage of the Endangered Species Act of 1973 refocused the activities of the Service as well as other governmental agencies. This Act mandated the conservation of threatened and endangered species of fish, wildlife, and plants both through Federal action and by encouraging the establishment of State programs. In the late 1970s, the Bureau of Wildlife and Sport Fisheries was renamed the U.S. Fish and Wildlife Service to broaden its scope of wildlife conservation responsibilities to include endangered species, as well as game and nongame species. A myriad of other conservation-oriented laws followed, including the Fish and Wildlife Conservation Act of 1980, which emphasized the conservation of nongame species.

The Service has no "organic" act to focus upon for the purposes of generating an agency mission. The agency mission has always been derived in consideration of the various laws (as listed in Section 2 of this Unit) and treaties that collectively outlined public policy concerning wildlife conservation. The Department of the Interior Manual states:

> *"The U.S. Fish and Wildlife Service is responsible for conserving, enhancing, and protecting fish and wildlife and their habitats for the continuing benefit of people through Federal programs relating to wild birds, endangered species, certain marine mammals, inland sport fisheries, and specific fishery and wildlife research activities."*[33]

[33] Departmental Manual 142 DM 1.1.

Refuge System: Mission and Goals -- The National Wildlife Refuge System (System) is the only existing system of Federally owned lands managed chiefly for the conservation of wildlife. The System mission is a derivative of the Service mission. This mission was most recently revised by the President of the United States in Executive Order 12996 to reflect the importance of conserving natural resources for the benefit of present and future generations of people. The Executive Order states:

> *The mission of the National Wildlife Refuge System is to preserve a national network of lands and waters for the conservation and management of fish, wildlife, and plant resources of the United States for the benefit of present and future generations.*

The Executive Order continues by specifying broad guiding principles describing a level of responsibility and concern for the nation's wildlife resources for the ultimate benefit of the people. These principles are as follows:

> ***Public Use***: The Refuge System provides important opportunities for compatible wildlife-dependent recreational activities involving hunting, fishing, wildlife observation and photography, and environmental education and interpretation.
>
> ***Habitat***: Fish and wildlife will not prosper without high-quality habitat, and without fish and wildlife, traditional uses of refuges cannot be sustained. The Refuge System will continue to conserve and enhance the quality and diversity of fish and wildlife habitat within refuges.
>
> ***Partnerships***: America's sportsmen and women were the first partners who insisted on protecting valuable wildlife habitat within wildlife refuges. Conservation partnerships with other Federal agencies, State agencies, Tribes, organizations, industry, and the general public can make significant contributions to the growth and management of the Refuge System.
>
> ***Public Involvement***: The public should be given a full and open opportunity to participate in decisions regarding acquisition and management of our National Wildlife Refuges.

4.3 Refuge Purpose Statements [34]

Formal establishment of a unit of the National Wildlife Refuge System is usually based upon a specific statute or executive order specifically enumerating the purpose of the particular unit. However, refuges can also be established by the Service under the authorization offered in such laws as the Endangered Species Act of 1973 or the Fish and Wildlife Act of 1956. In these cases, lands are identified by the Service that have the right elements to contribute to the recovery of a species or the maintenance of habitat types. Oftentimes, the Service works in cooperation with private nonprofit organizations in efforts to acquire suitable lands. This is the case for the LRGV and Santa Ana NWRs. Both refuges were established under the authority of the Fish and Wildlife Act of 1956 and Migratory Bird Conservation Act.

LRGV NWR Purpose -- "... for the development, advancement, management, conservation, and protection of fish and wildlife resources..." 16 U.S.C. 742f(a)(4) "...for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude..." 16 U.S.C. f(b)(1) (Fish and Wildlife Act of 1956, 16 U.S.C. 742(a)-754, as amended.

Santa Ana NWR Purpose -- "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C.715d (Migratory Bird Conservation Act)

"...suitable for -- (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species..." 16 U.S.C. 460k-1 (Refuge Recreation Act)

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[34] Refuge purpose statements are primary to the management of each refuge within the refuge system. The purpose statement is the basis upon which primary management activities are determined. Additionally, these statements are the foundation from which "allowed" uses of refuge are determined through a defined "compatibility process."

5.0 Lower Rio Grande Valley NWR Management Program

5.1 Biological Diversity, Land Protection, and Wildlife and Habitat Management

GOAL: *To restore, enhance, and protect the natural diversity of the Lower Rio Grande Valley including threatened and endangered species on and off refuge lands, through (1) land acquisition when appropriate, (2) the management of habitat and wildlife resources on refuge lands; and, (3) by strengthening existing, and establishing new cooperative efforts with public and private conservation agencies, and other government jurisdictions including Mexico.*

A. Acquisition and Land Status Objectives

1. Continue to pursue acquisition goal of 132,500 acres for the Lower Rio Grande Valley NWR by purchasing fee title lands or conservation easements within the river corridor from willing sellers and other lands within the four county area that will contribute to the preservation and enhancement of any of the 11 biotic communities. Close escrow on approximately a minimum of 5,000 acres per year.[35]

2. Acquire lands (tracts) that will: (1) Provide for the protection of endangered species; (2) Assist in the achievement of a contiguous river wildlife corridor; (3) Enlarge established brush tracts or create corridors connecting tracts of native habitat; (4) Enhance or connect existing refuge tracts not on or near the river; and, (5) Protect isolated tracts of desirable habitat.

3. Rank lands to be acquired by degree of disturbance or vulnerability as follows: (1) Uncleared native brush land or old regrowth brush land with good species diversity; (2) Wetlands; (3) Tracts of regrowth brush land with lower species diversity but potential for enhancement; (4) Agricultural land (farmed or pasture), especially tracts that would connect substantially uncleared tracts or moderate to high successional stage revegetated tracts; (5) developed lands that if acquired, could connect tracts of native habitat.

4. In lieu of fee title acquisition, develop more opportunities to work with private landowners leading to the protection of biodiversity on private lands.

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[35] This minimum objective is based upon existing acquisition dollars. Should Congress appropriate additional dollars, the Service's objectives would be increased. The Service would prefer to complete the corridor as soon as possible so long as dollars and willing sellers are available.

5. Investigate the feasibility of acquiring salt extraction subsurface rights in the Sal del Rey Tract (#85) (Bentson family).

6. Develop a process for efficiently researching pipeline, power, and oil and gas development rights-of-ways affecting refuge lands and develop a comprehensive land status map showing easements and county roads.

7. Develop a comprehensive Environmental Impact Statement for international bridge projects in cooperation with the State Department, IBWC, and the Environmental Protection Agency.

8. Establish guidelines and standards for the construction of bridges across the Rio Grande so that they will not interfere with the purpose of the Rio Grande wildlife habitat corridor, in coordination with the State Department, IBWC, and the Environmental Protection Agency. The Pharr-Reynosa bridge will be used as a model.

B. Research Objectives.

1. Conduct floral and faunal inventories throughout the area of ecological concern, and develop monitoring strategies to detect significant population trends.

2. Enhance international coordination of habitat research and natural resources conservation with Mexican agencies and partners; promote binational efforts to protect natural habitats, wetlands, endangered species, and water quality.

3. Develop and encourage research on wildlife habitat/corridor requirements and benefits to the overall biodiversity of the LRGV ecosystem. This should be done in coordination with universities and State organizations, as well as existing Service programs (i.e., Partners in Flight).

4. Conduct research on revegetation techniques and their associated cost/benefit analyses. Monitor plant survival and growth rates, ecological succession, wildlife utilization, and exotic species occurrence on specific revegetated tracts. Whenever possible, coordinate these efforts with university, State, and Federal organizations.

5. Continue to work cooperatively with Mexican governmental agencies and universities to monitor and protect populations of rare and endangered flora and fauna. This objective includes ongoing conservation work on corridor segments linking the Rio Grande/Rio Bravo corridor to the Laguna Madre of Tamaulipas and the Sierra de los Picachos in the State of Nuevo Leon.

C. Endangered Species Objectives

1. Monitor populations of threatened and endangered floral and faunal species on Refuge tracts and throughout the area of ecological concern. Use GIS and Global Positioning Systems to document locations of populations of species of management concern.

2. Implement recovery objectives identified in the various T/E Recovery Plans.

3. In conjunction with the various lead offices for T/E species, determine T/E species needs on the Refuge and develop strategies to provide for such needs. These strategies include habitat enhancement and restoration, support for research and recovery actions through Section 6 or other funding sources, and propagation and reintroduction into appropriate sites.

4. Conduct Intra-Service consultations with the Ecological Services division, in compliance with Section 7 of the Endangered Species Act, for all refuge projects and actions which "may effect" a T/E species.

5. In coordination with the Ecological Services division, provide a forum for the general public and special interest groups to express and resolve concerns regarding perceived T/E species conflicts arising from the creation of the Refuge. This could include preparation and issuance of safe harbor agreements.

6. Strengthen the existing educational and interpretive programs regarding the presence and importance of T/E species in the LRGV ecosystem.

D. Revegetation and Habitat Management Objectives

1. Continue to protect and restore refuge lands containing any of the 11 biotic communities identified in the Land Protection Plan (LPP).

2. Continue to revegetate up to 1000 acres of refuge cropland per year with appropriate native plant species, based upon FY 1996 staffing and funding levels (see District Level Strategies). Continue to utilize Cooperative Farming Agreements, in coordination with refuge personnel and other funding sources, to implement revegetation of approximately 5% to 15% of refuge cropland each year. Prioritize revegetation of fields according to the following scale (with A being the highest priority):

A) Fields located immediately adjacent to the Rio Grande which would directly link habitat corridor segments.

B) All other fields adjacent to the Rio Grande, or which would directly link habitat corridor segments, or are adjacent to existing protected habitat tracts..

C) Fields (or strips) that would form firebreaks or visual barriers adjacent to roads or developed areas.

D) All other cultivated fields.

E) All other fallow or weedy fields.

Within this set of priorities, it should be noted that each Cooperative Farmer normally conducts revegetation work on the same tract(s), or as close as possible, to the refuge fields being farmed. Fallow and weedy fields are all those that were previously farmed, but have been abandoned or were unsuccessfully revegetated in the past.

3. The primary objective of revegetation is to restore high-quality habitat on disturbed sites (mainly croplands), modeled on undisturbed sites with similar characteristics, in the minimum length of time.

4. Utilize revegetation strategies and techniques that optimize the following objectives, prioritized in the order listed:

A) Provide a diversity and composition of native plant species modeled on the vegetation of undisturbed sites with similar characteristics.

B) Yield the highest possible cost/benefit ratio (the balance of the greatest quality and amount of habitat produced for the lowest cost). Within this objective, achieving quality restoration work is more important than quantity, although both are important. Quality is a somewhat subjective judgement based on adherence to the diversity and composition objective (above), plant survival rates, growth rates and *in-situ* reproduction.

Quantity of restoration is based on acreage, *after* adjusting for failure rates.

C) Enhance the post-planting ecological succession of restored sites to generate diverse biotic communities resembling habitat on undisturbed sites. This objective is accomplished through planting patterns, spacing, composition and site preparation which will stimulate *in-situ* regeneration of plants, introduction of additional native plants through faunal and abiotic vectors, and colonization by native fauna.

D) Minimize the impact of perennial exotic species, the most significant of which are the exotic grass species and Russian Thistle *(Salsola kali)*.

5. Identify areas believed to have been grasslands or savanna at the time of Spanish colonization; possible sites may be found at the Sal del Rey Tract (#85) and Rudman portion of the Teniente Tract (#41) in the Northern Hidalgo County District. Develop techniques for restoring these unique plant communities and implement their restoration at suitable sites.

6. Identify areas subject to gully erosion and plant native grass waterways.

7. Develop and stimulate research on revegetation techniques and results, in coordination with university, State, and Federal entities.

8. Construct and maintain existing fencing on those revegetated refuge tracts prone to trespassing, illegal dumping, and illegal burning.

9. Evaluate the feasibility of enhancing revegetation efforts through an experimental grazing program. The objective of this grazing program would be to suppress exotic grasses that have invaded previously revegetated sites. Additionally, grazing could reduce fuel loads and wildfire potential. This would entail coordination with experts in the County Agricultural Extension Program for development, implementation, and monitoring of effects. As part of the development of an overall experimental grazing program, design an experimental grazing allotment with assistance from the County extension agent specifically on the Noriega Tract (#57), Cameron County District, and the Teniente (#41) or Sal del Rey (#85) tracts in the Upper Hidalgo/ Willacy County District.

E. Fire Management

1. Use a combination of strategies such as discing, prescribed fire, and herbicides (depending on location and other factors) to control and lessen fuel loads in areas susceptible to high growth levels of bermuda and other exotic grasses and Russian thistle, especially tracts within the Hidalgo County District as 40% of all suppressed fires in the LRGV are in that area. Areas would not be reforested until these exotics are removed.

2. Presuppression / Suppression -- The refuge will maintain a standing force of fire program personnel whose primary duty will be to detect and suppress those wildfires found on the refuge.[36]

3. Prescribed fire

A) Fire management staff will inventory small riparian areas and other refuge holdings where exotic plants have become prolific and for wildland/urban reasons, adjacent threatened native habitat or possible road hazards where wildfire could occur.

B) Develop plans for approval that would mitigate the impacts from a hazard mitigation standpoint and from the possible socio-economic and political implications.

C) Inventory in cooperation with biological staff those areas of the refuge that might be in need of habitat enhancement prescribed burning strategies in an effort to mimic historic natural fires and thus benefit overall habitat health.

4. Staffing and Equipment -- In order to meet the needs of this expanding work load ongoing assessments of property acquisitions, fire occurrence, illegal activity (i.e., human presence) will have to be made annually to insure that the refuge's needs are being met

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[36] The Standard or average burning or wildfire season for the LRGV has been determined to be 10 months per year. Occasionally, there are seasons of 12 months. A great number of wildfire ignitions occur on the Complex's property each year (approximately 50-75 ignitions per year). Suppression is mandated by Agency policy and Federal Law for all fires that are not naturally ignited or ignited intentionally by the agency for an accepted purpose and they must be burned in accordance with a pre-approved prescribed burn plan. Due to the Wildland/Urban interface presence next to a number of refuge tracts, the fact that the complex is continuing to acquire land and the probability that criminal activities such as smuggling etc. will continue to increase it is anticipated that the wildfire ignitions will also remain an upward trend. This requires and will require a standing force of fire program personnel whose primary duty will be to detect and suppress those wildfires found on the refuge.

5. Coordination with Other Agencies -- Please refer to Section F. Below, Partnerships and Cooperative Efforts.

F. Law Enforcement

1. In order to ensure the protection of refuge lands' resources, the LRGV will establish a total of five full time permanent law enforcement positions in accordance with the LRGV NWR Complex Law Enforcement Review of 1993.

G. Partnerships and Cooperative Efforts

1. The Service would continue to seek partnership opportunities with TPWD leading to the resolution of wildlife, plant, and habitat issues in the LRGV especially for tracts which have common borders. Partnerships could include cooperative management efforts with respect to: law enforcement; biological inventories, monitoring, and research; public use; and, other activities in a manner that would provide mutual benefits to each agency with a greater efficiency of available resources.

2. The Service would continue to seek partnership opportunities with Mexico, other Federal, State and local government agencies, and non-governmental organizations to meet common goals and objectives.

3. Fire Management -- Due to the great number of local, State, and Federal agencies operating in and around the LRGV and refuge holdings, it is essential that a great deal of effort be committed to coordination. Close working relationships will be established with all concerned fire agencies as well as with other overlapping jurisdictions such as emergency rescue, law enforcement, and civil disaster preparedness agencies. Since all fire management resources are regional and national resources as well as refuge resources, it is necessary for the program supervisor to maintain close coordination with the zone dispatch center managers, and the Service's regional coordinator. It is also necessary for the fire program supervisor to keep the appropriate refuge line officer appraised and up to date on refuge fire situations as well as anticipated needs off refuge.

5.2 Water Rights, Water Management and the Management of Wetlands

GOALS: (1) To protect existing water rights holdings in the Area of Ecological Concern and obtain additional water rights, to the extent needed. (2) To improve the efficiency of water delivery systems and more effectively gauge water use for the benefit of refuge revegetation purposes and wetland restoration and enhancement purposes. (3) To achieve wetlands protection, enhancement, and rehabilitation within the Area of Ecological Concern.

OBJECTIVES:

1. Protect and enhance 44 various wetland areas consisting of approximately 193 acres refuge wide by completion of various restoration projects to include installation and/or repair of water control structure, delivery systems, culverts, and dikes (See Refuge District Strategies).

2. Continue to acquire tracts with restorable or existing wetlands.

3. Develop an inventory of existing and historic wetlands on Refuge lands.

4. Establish criteria to determine baseline conditions for wetland restoration/enhancement projects prior to implementation.

5. Develop a monitoring program to determine the long term success of wetland conservation/restoration projects in terms of water quality, animal use, etc...(in coordination with E.S., universities, etc...)

6. Use prescribed burning in wetland areas to maintain or stimulate desirable plant and water conditions.

7. Without adversely affecting other entitlement holders, protect 16,000 acre feet of existing allocated water rights (purchased fee simple) by working with Texas Water Commission to ensure that refuges uses are judged to be "beneficial uses."

8. Acquire additional water rights when they become available refuge-wide.

9. Continue to assist non-refuge conservation entities such as Sabal Palm Grove with refuge allocated water.

10. Continue to maintain La Selva Verde Tract (470 acres) and Laguna Atascosa NWR water right from the Nueces/Rio Grande Basin right of 750 acre/feet.

11. Work with Regional Department of the Interior Solicitor and TNRCC in developing a water right policy defining water right flexibility to include an understanding of the following:

(a) the legalities of contracting or selling water to maintain right,
(b) the possible exchange of water rights for work performed,
whether property could be traded for water rights.

Based upon the findings and recommendations of the Solicitor and the State of Texas develop a water right management objectives.

12. Investigate the possible use of subsurface waters through the use of windmills and stock tanks, especially on tracts farthest away from the river.

13. Continue to record and document the need and use of water on the refuge. Advise regional water rights coordinator of water rights use and activities.

14. Improve the efficiency of water delivery systems and effectively gauge water use for the ultimate benefit and enhancement of habitat and wildlife.

15. Coordinate water management activities with the Bureau of Reclamation, Corps of Engineers/IBWC/ and the State in the development of a system-wide water management plan.

16. Continue to work with irrigation districts throughout the Lower Rio Grande Valley to minimize water use costs derived from assessment fees.

17. Continue to use irrigation districts to pump and deliver water when necessary.

18. Continue to maintain, develop, restore, or improve water systems for the following groupings of Tracts:

A. Abram (#22), La Parida B. (#23), Palmview (#24) and El Morillo B. (#25).
B. Gabrielson (#28), Granjeno (#29), and Cottam (#30)

C. Marinoff (#35), Milagro (#72), and Monterrey B. (#38)

D. Santa Maria (#45), Villitas (#46), La Gloria (#82), Resaca del Rancho Viejo (#49), and Resaca Fresnos (#68)

E. Ranchito (#54), Tahuachal Banco (#69), Garza-Cavazos (#55)

F. Boscaje (#59), Jeronimo Banco (#88)

19. Initiate and/or complete the following wetland restoration projects in order of priority as presented in the following table:

TRACT	County District	WETLANDS	ACRES	% complete	PROJECT TYPE
(1) El Morillo Banco (#25)	Hidalgo	1	50	30%	delivery, control structure
(2) Teniente (#41)	Willacy	17	143	50%	ditch plugs, control structure, delivery
(3) Ranchito (#54)	Cameron	8	170	75%	control structure, delivery
(4) La Selva Verde (#78)	Cameron	6	397	75%	control structure, ditch plugs, delivery
(5) Resaca del Rancho Viejo (#49)	Cameron	1	25	50%	delivery
(6) La Gloria (#82)	Cameron	1	20	75%	dike install., control structures
(7) Valadeces Banco (#11)	Starr	1	35	0%	delivery, land agreement
(8) Tahuachal Banco (#69)	Cameron	1	20	0%	delivery, dike install
(9) Los Velas (#66)	Starr	1	15	0%	control structure

20. Work with IBWC to insure major components of Memorandum of Agreement are adhered to with respect to reducing width of mowed areas from 235 feet to 75 feet along a 34 mile stretch of river beginning at the weir above Brownsville.

21. Pursue development of a revegetation management plan for the riparian edges along the flood control system in cooperation with the IBWC.

22. Perfect water rights in the lower Rio Grande Basin and the Nueces/ Rio Grande Coastal Basin areas. Investigate rights needed to pump from Coastal Basin drainage ditches.

5.3 Water Quality and Contaminants

GOAL: (1) To improve refuge water quality and ensure water management projects are monitored for contamination and, (2) to reduce contaminant related fish and wildlife resource losses on lands and waters and minimize any impacts that are unavoidable.

OBJECTIVES:

1. Improve understanding of the effects of contamination on Lower Rio Grande Valley species in coordination with state and federal entities.

2. Establish consistent implementation of state and federal water quality standards by establishing long term cooperation with the State's water quality officials.

3. Continue to work with the Division of Ecological Services, and TNRCC by providing data regarding salt content of the Rio Grande as well as other non-point source contaminants that affect soils and resources on Service lands.

4. Using an ecosystem approach, coordinate with the Division of Ecological Services, IBWC, and Corps of Engineers, and other state and federal agencies in periodically sampling water in various segments of the river, drainage ways, resacas, and wetland areas within refuge lands.

5. Using an ecosystem approach, coordinate periodic meetings with Division of Ecological Services and the Texas Water Commission to discuss water concerns within the LRGV ecosystem.

6. Monitor public uses, concentrations, and effects on water, land, and wildlife resources in an effort to understand the effects of human uses on the LRGV ecosystem..

7. In coordination with the Division of Ecological Services, continue to identify and categorize those areas on the Refuge in need of contaminant clean-up.

8. Prioritize, in coordination with Division of Ecological Services, areas on the Refuge in need of sampling for possible contaminants (soil, water, etc.).

9. In coordination with the Division of Ecological Services, prioritize those area on the refuge consisting of illegal dump-sites containing household garbage and implement clean-up.

10. Educate local communities about the need to reduce illegal trash dumping on Service and other LRGV corridor lands and participate and assist in Lower Rio Grande Valley clean up days and tire amnesty days.

11. Work with County officials in the counties along the river to develop additional legal dump sites. Increase patrols of gates and fences.

12. Work with oil and gas developers to reduce soil and water contamination incidents resulting from oil and gas leaks.

5.4 Cultural Resources

GOAL: To protect, maintain, and plan for Service managed cultural resources on the Lower Rio Grande Valley / Santa Ana NWR for the benefit of present and future generations.

OBJECTIVES:

1. Coordinate with SHPO to identify cultural resources on the refuge. Evaluate the status of new sites such as the Casa Yanqui ruins in the Starr County District and submit for additional protection (i.e., National Register) if necessary.

2. Develop mechanisms and tools to assist in the education of local communities of the importance of Lower Rio Grande Valley cultural resources.

3. Develop opportunities for the public appreciation of identified cultural resource areas in coordination with the Camino del Rio project.

4. Integrate a cultural resource information component into the interpretive program at Santa Ana NWR.

5. Establish interpretive kiosk, or site at La Sal del Rey Tract (#85) Historic Site, the Hidalgo Pump House (Pate Bend Tract (#31), and establish an interpretive/ rest stop for the Palmito Ranch Battlefield (National Historical Landmark) in cooperation with the State at

Tulosa Ranch Tract (#60) and Palmito Hill Tract (#61) [See also, Goal 5 below.].

6. Research and record history of LRGV NWR tracts and consider developing a specific tract displays in the refuge visitor center.

5.5 Public Use, Recreation, and Wildlife Interpretation & Education

GOALS: (1) To continue to offer a quality wildlife observational trail system on Santa Ana NWR.. (2) To offer compatible wildlife-dependent public access and recreational opportunities on tracts of the Lower Rio Grande Valley NWR that result in furthering the public's appreciation of Lower Rio Grande Valley Area of Ecological Concern and the National Wildlife Refuge System. This will be done by the provision of wildlife observation, photography, fishing, and hunting recreational opportunities in accordance with Executive Order 12996.[37] *(3) To continue wildlife interpretation and educational efforts at Santa Ana NWR and initiate interpretive efforts for Lower Rio Grande Valley NWR in coordination with private groups and other jurisdictions.*

OBJECTIVES

1. Work with local conservation organizations to develop a long range plan to reestablish and continue tram Services at Santa Ana NWR.

2. Strengthen the existing educational and interpretive programs and develop new approaches towards describing and disseminating information on the interrelationships between all the organisms (plant/animal/insect) which contribute to Lower Rio Grande Valley biological diversity.

3. Establish 3 interpretive centers on refuge lands in Cameron County District, Hidalgo County District, and Starr County District either by the placement of kiosks or eventual establishment of satellite offices.

4. Consider establishment of limited levels of compatible public access for wildlife observation and, photography on the following LRGV NWR Tracts:Ytrurria Brush Tract (#18), La Sal Vieja-Sal del

[37]Recreational uses are considered Compatible when they do not "materially detract from or interfere with the purposes for which a refuge is established."

Rey Tracts (#85), Monte Cristo Tract (#26), La Puerta (#5), Boca Chica Area, and/or the Schaleben Tract (#37).[38]

5. Work with TPWD to evaluate deer herd population (5-year) trends in the East Lake Teniente Tract (#41). Establish a deer hunt if the trend analysis demonstrates a harvestable surplus and if the proposed activity is determined compatible in accordance with policy and law.

6. Establish interpretive kiosk, or site at La Sal del Rey Tract (#85), the Hidalgo Pump House (Pate Bend Tract (#31), and establish an interpretive/ rest stop for the Palmito Hill Battlefield (National Historical Landmark) in cooperation with the State at Caja Pinta Banco Tract (#79), Tulosa Ranch Tract (#60) and Palmito Hill Tract (#61).

7. Strengthen Refuge public outreach in the Starr County District by developing a bilingual outreach capability for that area.

8. Establish a "Friends" support organization in order to improve community relations and achieve refuge objectives.

9. Initiate strategies leading to enhanced cooperative efforts between the Service, TPWD, other state and federal agencies, Mexico, and non governmental organizations as delineated in Goal 1 F.

[38]With respect to considering opening up certain tracts to limited access, the Service has given priority to those tracts away from the main river channel and corridor for two reasons: (1) The river areas consist of smaller tracts that may not be appropriate for access; (2) Existing opportunities for wildlife observation are present at Santa Ana NWR, Sabal Palm Grove, Bentsen-Rio Grande and the Falcon Dam area. Opportunities exist at other sites along the river for fishing access. At any point where the Service decides to consider implementation of public access on sites presently closed, the new use will be analyzed with respect to its "compatibility." In addition, the Service would have to filter proposed actions through the Refuge Recreation Act Funding Certification analysis. Finally, additional site specific NEPA consideration may also be necessary.

Establishing public access at some of the larger off-river sites is justified because of their size and they can accommodate very simple forms of public access [wildlife photography and observation] where disturbance can be monitored and minimized. The smaller tracts along the corridor are much less able to absorb effects and impacts of access and uses. The exception might be the sizeable Boca Chica Tract at the delta where beach access will continue. The Service is also willing to consider continuing access to fishing areas on river portions of the Boca Chica Tract.

6.0 Santa Ana NWR Management Program

6.1 Biological Diversity, Land Protection, and Wildlife and Habitat Management

GOAL: *To restore, enhance, and protect the natural diversity of the Lower Rio Grande Valley including threatened and endangered species on and off refuge lands, through (1) land acquisition when appropriate, (2) the management of habitat and wildlife resources on refuge lands; and, (3) by strengthening existing, and establishing new cooperative efforts with public and private conservation agencies, and other government jurisdictions including Mexico.*

A. Acquisition and Land Status Objectives

1. Continue to investigate the feasibility of acquiring the farm fields along the east and west boundary of Santa Ana.

2. Investigate the feasibility of acquiring the Mesa family land in the northwest corner of the Santa Ana headquarters area.

B. Scientific Data Objectives

1. Develop and implement a biological Inventory and Monitoring Plan (IMP) for Santa Ana in accordance with 701 FW 2. The IMP will enable the refuge to focus limited resources on data collection that is pertinent to Service policies and programs and to management objectives of Santa Ana NWR.

2. Continue and improve coordination of international habitat research and conservation with Mexican agencies and partners especially those pertaining to native habitat protection including wetlands, endangered species, and water quality.

3. Develop and encourage cooperative research on the refuge with university and state entities, as well as with existing Service programs (e.g., Partners in Flight). Cooperative research will make efficient use of limited funds, help avoid duplication of effort, and promote an ecosystem approach to land management.

C. Endangered Species Objectives

1. Determine the existence of threatened and endangered floral and faunal species on Santa Ana NWR by developing and implementing a

long term Inventory and Monitoring Plan. Use GIS and GPS to document locations of endangered flora.

2. Implement recovery objectives identified in the various T/E Recovery Plans.

3. In conjunction with the various T/E species' lead offices, determine T/E species needs on the Refuge and develop strategies to provide for such needs. These strategies should include habitat enhancement, funding and research opportunities, (Section 6, University, conservation organization, Service Division of Research etc.), propagation and others.

4. Ensure protection of T/E species through compliance with Section 7 of the Endangered Species Act by initiating Intra-Service Section 7 consultations with the Services Office for projects/actions which "may affect" T/E species.

5. Strengthen existing educational and interpretive programs and develop new approaches towards describing and disseminating information regarding the presence and importance of T/E species in the LRGV-ecosystem.

D. Revegetation and Habitat Management Objectives

1. Revegetate grassy areas near the refuge entrance road and visitor center with native brush species.

2. Revegetate grassy areas in "Bravo Woods" with native brush species.

3. Remove buildings from old headquarters area. Revegetate to return area to wildlife habitat.

4. Develop pilot program to control non-native grasses on roadsides and replant with native grass species.

5. Maintain fencing, gates, and boundary signs on the refuge to prevent plant poaching and illegal dumping. Increase patrols. Promptly clean up any dump sites.

E. Fire Management

1. Continue to keep roadsides mowed to reduce fuel load.

2. Avoid stacking fuel on the refuge when trimming trees and brush. Use chipper when feasible.

F. Law Enforcement

1. Ensure visitor safety and the protection of refuge resources by establishing a total of five full time permanent law enforcement positions in accordance with the LRGV NWR Complex Law Enforcement Review of 1993.

2. Increase presence of uniformed staff and volunteers on trails and in the parking lot.

3. Investigate possible upgrade of surveillance camera equipment for the visitor parking lot.

4. Install sign in visitor center parking area reminding visitors to lock their vehicles and stow valuables.

G. Partnerships and Cooperative Efforts

1. Continue to seek partnership opportunities with TPWD leading to the resolution of wildlife, plant, and habitat issues in the LRGV especially for tracts which have common borders. Partnerships could include cooperative management efforts in: law enforcement; biological inventories, monitoring, and research; public use; and other activities in a manner that would provide mutual benefits to each agency with a greater efficiency of available resources.

2. Continue to seek partnership opportunities with Mexico, other Federal, State and local government agencies, and non-governmental organizations to meet common goals and objectives.

6.2 Water Rights, Water Management and the Management of Wetlands

GOALS: (1) To protect existing water rights holdings in the Area of Ecological Concern and obtain additional water rights, to the extent needed. (2) To improve the efficiency of water delivery systems and more effectively gauge water use for the benefit of refuge revegetation purposes and wetland restoration and enhancement purposes. (3) To achieve wetlands protection, enhancement, and rehabilitation within the Area of Ecological Concern.

OBJECTIVES

1. Continue to update and implement the Santa Ana NWR Water Management Plan.

2. Protect and enhance wetland areas on Santa Ana by installation and/or repair of water control structures, delivery systems, culverts, and dikes for the ultimate benefit of habitat and wildlife.

3. Continue to document the need for and use of water on the refuge. Develop and maintain a computerized inventory of water use and wetland water levels.

4. Restore the historic flooding regime in Santa Ana flood forest areas each spring by pumping water from the Rio Grande. Use GPS and GIS to delineate the boundaries of the flooded area. Develop program to monitor long term effects of the restored flooding regime.

5. Continue to maintain a diversity of water levels and habitat conditions in refuge resacas to benefit a broad spectrum of wetland-dependent native flora and fauna.

6. Use a program of drying, mowing, discing, and prescribed burning in wetland areas to maintain or stimulate desirable plant and water conditions.

7. As part of IMP, develop and implement monitoring program to evaluate success of wetland management program in terms of water quality, habitat quality, animal use, etc.

6.3 Water Quality and Contaminants

GOAL: (1) To improve refuge water quality and ensure water management projects are monitored for contamination and, (2) to reduce contaminant-related fish and wildlife resource losses on lands and waters and minimize any impacts that are unavoidable.

OBJECTIVES

1. Improve understanding of the effects of contamination on Lower Rio Grande Valley species in coordination with state and federal entities. Coordinate periodic meetings with Division of Ecological Services and the Texas Water Commission to discuss water concerns within the LRGV ecosystem.

2. Prioritize areas on the refuge in need of sampling for contaminant levels (soil, water, etc.) as part of the Inventory and Monitoring Plan.

3. Using an ecosystem approach, coordinate with other state and federal agencies to begin studies on contaminant levels in Santa Ana wetlands, the effects of contaminants on local flora and fauna, and possible mitigation strategies.

4. Continue efforts to reduce, reuse, and recycle waste in all refuge programs.

5. Educate local communities about the need to reduce illegal trash dumping and participate and assist in Lower Rio Grande Valley clean up days and tire amnesty days.

6.4 Cultural Resources

GOAL: To protect, maintain, and plan for Service managed cultural resources on the Lower Rio Grande Valley / Santa Ana NWR for the benefit of present and future generations.

OBJECTIVES

1. Develop mechanisms and tools to assist in the education of local communities of the importance of Lower Rio Grande Valley cultural resources.

2. Develop opportunities for the public appreciation of identified cultural resource areas in coordination with the Caminos del Rio project.

3. Integrate a cultural resource information component into the interpretive program at Santa Ana NWR.

4. Develop a cultural resource brochure and display for the visitor center.

5. Maintain and landscape historic areas on refuge such as the Old Cemetery and the Santa Ana Land Grant interpretive sign near the visitor center.

6.5 Public Use, Recreation, and Wildlife Interpretation & Education

GOALS: (1) To continue to offer a quality wildlife observational trail system on Santa Ana NWR.. (2) To offer compatible wildlife-dependent public access and recreational opportunities on tracts of the Lower Rio Grande Valley NWR that result in furthering the public's appreciation of Lower Rio Grande Valley Area of Ecological Concern and the National Wildlife Refuge System. This will be done by the provision of wildlife observation, photography, fishing, and hunting recreational opportunities in accordance with Executive Order 12996. (3) To continue wildlife interpretation and educational efforts at Santa Ana NWR and initiate interpretive efforts for Lower Rio Grande Valley NWR in coordination with private groups and other jurisdictions.

OBJECTIVES

1. Work with local conservation organizations to develop a long-range plan to continue tram services at Santa Ana NWR.

2. Develop and implement an updated sign plan. Replace worn and outdated interpretive signs and develop additional ones. Replace entrance sign. Work with the Texas Department of Transportation to place additional Santa Ana directional signs on area highways.

3. Develop and install updated visitor center exhibits.

4. Develop new interpretive materials for visitors, e.g. brochures on plant communities, the Wildlife Corridor, and general Santa Ana NWR information; and an interpretive audio cassette for visitors driving the tour loop.

5. Strengthen outreach, environmental education, and wildlife-oriented recreational opportunities for Spanish-speaking visitors. Develop more interpretive programs and materials in Spanish.

6. Strengthen communication between federal, state, local, and private agencies interested in environmental education and public outreach. Establish a Valley-wide working group of environmental educators to share ideas, coordinate activities, and develop a joint effort to promote quality environmental education in south Texas and Mexico.

7. Maintain trails, signs, parking lot, visitor center, and public restrooms to high standards of cleanliness and repair.

8. Investigate the feasibility of initiating a fee collection program at Santa Ana NWR.

9. Establish a "Friends" support organization to improve community relations and achieve refuge objectives.

10. Continue to seek funding for tour loop and parking lot repair.

11. Evaluate the need for new overlooks, photo blinds, and parking areas along refuge roads and trails. Initiate necessary improvements.

7.0 Refuge Management Strategies by District

7.1 Starr County District Strategies

1. Reassess acquisition needs in Starr County and improve the connection of the fragmented small parcels that have not coalesced into a manageable unit especially in the Grulla Tract area.

2. Improve habitat and wildlife suitability by developing small fresh water sites on lands farther away from the River such as Los Olmos Tract (#86) and La Puerta Tract (#5). If possible repair old windmills present on the sites.

3. Increase monitoring of fencing and repair when necessary on revegetated tracts such as Los Velas Tract (#66) to prevent entry by people or cattle. Hire an additional law enforcement person to provide more presence on these tracts to prevent poaching of deer, javelina, and peyote.

4. Continue to monitor and protect threatened and endangered plant species such as Walker's Manioc, Johnston's Frankenia, Zapata Bladderpod, Ashy Dogweed and Star Cactus by placing each known plant on the GPS system coordinates.

5. Use GIS and GPS to conduct improved floristic surveys, especially on tracts subject to oil and gas exploration.

6. Continue to revegetate cropland in proportion to total farm acreage managed by the refuge in Starr County. In September, 1997, 418.0 acres of refuge cropland were covered under Cooperative Farming agreements in Starr County; this represents 4% of the total refuge Cooperative Farming acreage of 10,370.7 acres.

7. Restore Starr County District wetlands as follows: Valadeces Banco (#11) 1 wetland totaling 35 acres, (priority 9 of 11); and, Los Velas Tract (#66) 1 wetland totaling 15 acres, (priority 11 of 11).

8. Dedicate a new Full Time Equivalent (FTE)T to concentrate on oil and gas issues including assessing value on vegetation in areas subject to exploration or development, Section 7 consultations, Section 404 wetland permits, and developing cooperative agreements with owners of mineral rights.

9. Evaluate status and explore elevating level of protection (i.e., national register) of the Casa Yanqui ruins.

10. Strengthen Refuge public outreach in the Starr County District by developing a bilingual outreach capability for that area. Outreach should include contacts with schools and chamber of commerce offices in Rio Grande City.

11. Develop cooperative agreements with farmers to farm tracts prone to be fire hazards because of grasses and weeds, provide extra protection until fire danger is reduced.

7.2 Southern Hidalgo District Strategies

1. Continue to revegetate cropland in proportion to total farm acreage managed by the refuge in Hidalgo County (exclusive of the area covered in section 7.4). In September, 1997, 1,501.7 acres of refuge cropland were covered under Cooperative Farming agreements in lower Hidalgo County; this represents 14% of the total refuge Cooperative Farming acreage of 10,370.7 acres. Revegetation will be completed on 144.2 acres in lower Hidalgo County by February, 1998.

2. Develop cooperative agreements with farmers to farm tracts prone to be fire hazards because of grasses and weeds, provide extra protection until fire danger is reduced.
3. Work with Hidalgo County to establish more legal trash dump sites. Increase monitoring of fences and gates and along roads and areas between refuge tracts and adjacent owners. Target tracts for illegal trash reduction include: Sam Fordyce (#19), Havana (#20).

4. Develop educational outreach training or seminars for Border Patrol agents, and USDA (Tick Eradication Program) so they better understand the Service's mission in the Lower Rio Grande Valley, and request that the Border Patrol and USDA provide additional training and orientation with respect to their mission, goals and objectives in the Lower Rio Grande Valley.

5. Continue efforts to improve and restore El Morillo Banco Tract (#25) wetlands. Design and install improved pump site and investigate funding options to be able to deliver water seasonally. Options include paying a water district, or to use the Refuge water rights.

6. Restore and manage wetlands in the following tracts in this management district: El Morillo Banco (#25), 1 wetland totaling 50 acres, (priority 3 of 11); Willow Lake at Santa Ana NWR, 6 wetlands totaling 38 acres, (priority 1 of 11); Cattail Lake at Santa Ana NWR, 1 wetland totaling 70 acres, (priority 2 of 11).

7. Request the Office of the Solicitor to answer pending legal questions with respect to the legitimacy of water district assessments.

8. Develop interpretive materials for the Hidalgo Bend pump house in coordination with the Camino del Rio program. Participate in development of guided tram program and/or trail.

9. Develop and/or update interpretive materials for the Santa Ana NWR National Natural Landmark along with the grave yard, and Texas historical monuments.

10. Develop interpretive signing on boundary of lands adjacent to parks or lands with high public use inviting them to look in but not walk in. Includes tracts such as: El Morillo Banco (#25) and La Parida Banco (#23).

11. Continue to reduce the level of trespass in the Otha Holland Wildlife Corridor / Delta Lake Canal (#75). Continue to patrol and maintain signs and fences. Within 5 years, amend or renegotiate corridor agreement to exclude the lake from the agreement. Terminate the corridor at the highway and exclude fencing from the agreement and exclude other problem areas that are of little wildlife benefit.

12. Continue to monitor and protect threatened and endangered plant species such as *Ayenia limitaris* by placing each known plant on the GPS system coordinates.

13. Use GIS and GPS to conduct improved floristic surveys, especially on tracts subject to oil and gas exploration.

Santa Ana NWR Specific Strategies

14. Continue to investigate the feasibility of acquiring the farm fields along the east and west boundary of Santa Ana.

15. Investigate the feasibility of acquiring the Mesa family land in the northwest corner of the Santa Ana headquarters area.

16. Develop and implement a biological Inventory and Monitoring Plan (IMP) for Santa Ana in accordance with 701 FW 2. The IMP will enable the refuge to focus limited resources on data collection that is pertinent to Service policies and programs and to management objectives of Santa Ana NWR.

17. Continue and improve coordination of international habitat research and conservation with Mexican agencies and partners especially those pertaining to native habitat protection including wetlands, endangered species, and water quality.

18. Develop and encourage cooperative research on the refuge with university and state entities, as well as with existing Service programs (e.g., Partners in Flight). Cooperative research will make efficient use of limited funds, help avoid duplication of effort, and promote an ecosystem approach to land management.

19. Determine the existence and habitat needs of threatened and endangered species on Santa Ana NWR by developing and implementing a long term Inventory and Monitoring Plan. Use GIS and GPS to document locations of endangered flora.

20. Implement recovery objectives identified in the various T/E Recovery Plans.

21. In conjunction with the various T/E species' lead offices, determine T/E species needs on the Refuge and develop strategies to provide for such needs. These strategies should include habitat enhancement, funding and research opportunities, (Section 6, University, conservation organization, Service Division of Research etc.), propagation and others.

22. Ensure protection of T/E species through compliance with Section 7 of the Endangered Species Act by initiating Intra-Service Section 7 consultations with the Services Office for projects/actions which "may affect" T/E species.

23. Strengthen existing educational and interpretive programs and develop new approaches towards describing and disseminating information regarding the presence and importance of T/E species in the LRGV ecosystem.

24. Revegetate grassy areas near the refuge entrance road and visitor center with native brush species.

25. Revegetate grassy areas in "Bravo Woods" with native brush species.

26. Remove buildings from old headquarters area. Revegetate to return area to wildlife habitat.

27. Develop pilot program to control non-native grasses on roadsides and replant with native grass species.

28. Maintain fencing, gates, and boundary signs on the refuge to prevent plant poaching and illegal dumping. Increase patrols. Promptly clean up any dump sites.

29. Continue to keep roadsides mowed to reduce fuel load.

30. Avoid stacking fuel on the refuge when trimming trees and brush. Use chipper when feasible.

31. Ensure visitor safety and the protection of refuge resources by establishing a total of five full time permanent law enforcement positions in accordance with the LRGV NWR Complex Law Enforcement Review of 1993.

32. Increase presence of uniformed staff and volunteers on trails and in the parking lot.

33. Investigate possible upgrade of surveillance camera equipment for the visitor parking lot.

34. Install sign in visitor center parking area reminding visitors to lock their vehicles and stow valuables.

35. Continue to seek partnership opportunities with TPWD leading to the resolution of wildlife, plant, and habitat issues in the LRGV especially for tracts which have common borders. Partnerships could include cooperative management efforts in: law enforcement; biological inventories, monitoring, and research; public use; and other activities in a manner that would provide mutual benefits to each agency with a greater efficiency of available resources.

36. Continue to seek partnership opportunities with Mexico, other Federal, State and local government agencies, and non-governmental organizations to meet common goals and objectives.

37. Continue to update and implement the Santa Ana NWR Water Management Plan.

38. Protect and enhance wetland areas on Santa Ana by installation and/or repair of water control structures, delivery systems, culverts, and dikes for the ultimate benefit of habitat and wildlife.

39. Continue to document the need for and use of water on the refuge. Develop and maintain a computerized inventory of water use and wetland water levels.

40. Restore the historic flooding regime in Santa Ana flood forest areas each spring by pumping water from the Rio Grande. Use GPS and GIS to delineate the boundaries of the flooded area. Develop program to monitor long term effects of the restored flooding regime.

41. Continue to maintain a diversity of water levels and habitat conditions in refuge resacas to benefit a broad spectrum of wetland-dependent native flora and fauna.

42. Use a program of drying, mowing, discing, and prescribed burning in wetland areas to maintain or stimulate desirable plant and water conditions.

43. As part of IMP, develop and implement monitoring program to evaluate success of wetland management program in terms of water quality, habitat quality, animal use, etc.

44. Improve understanding of the effects of contamination on Lower Rio Grande Valley species in coordination with state and federal entities. Coordinate periodic meetings with Division of Ecological Services and the Texas Water Commission to discuss water concerns within the LRGV ecosystem.

45. Prioritize areas on the refuge in need of sampling for contaminant levels (soil, water, etc.) as part of the Inventory and Monitoring Plan.

46. Using an ecosystem approach, coordinate with other state and federal agencies to begin studies on contaminant levels in Santa Ana wetlands, the effects of contaminants on local flora and fauna, and possible mitigation strategies.

47. Continue efforts to reduce, reuse, and recycle waste in all refuge programs.

48. Educate local communities about the need to reduce illegal trash dumping and participate and assist in Lower Rio Grande Valley clean up days and tire amnesty days.

49. Develop mechanisms and tools to assist in the education of local communities of the importance of Lower Rio Grande Valley cultural resources.

50. Develop opportunities for the public appreciation of identified cultural resource areas in coordination with the Caminos del Rio project.

51. Integrate a cultural resource information component into the interpretive program at Santa Ana NWR.

52. Develop a cultural resource brochure and display for the visitor center.

53. Maintain and landscape historic areas on refuge such as the Old Cemetery and the Santa Ana Land Grant interpretive sign near the visitor center.

54. Work with local conservation organizations to develop a long-range plan to continue tram services at Santa Ana NWR.

55. Develop and implement an updated sign plan. Replace worn and outdated interpretive signs and develop additional ones. Replace entrance sign. Work with the Texas Department of Transportation to place additional Santa Ana directional signs on area highways.

56. Develop and install updated visitor center exhibits.

57. Develop new interpretive materials for visitors, e.g. brochures on plant communities, the Wildlife Corridor, and general Santa Ana NWR information; and an interpretive audio cassette for visitors driving the tour loop.

58. Strengthen outreach, environmental education, and wildlife-oriented recreational opportunities for Spanish-speaking visitors. Develop more interpretive programs and materials in Spanish.

59. Strengthen communication between federal, state, local, and private agencies interested in environmental education and public outreach. Establish a Valley-wide working group of environmental educators to share ideas, coordinate activities, and develop a joint effort to promote quality environmental education in south Texas and Mexico.

60. Maintain trails, signs, parking lot, visitor center, and public restrooms to high standards of cleanliness and repair.

61. Investigate the feasibility of initiating a fee collection program at Santa Ana NWR.

62. Establish a "Friends" support organization to improve community relations and achieve refuge objectives.

63. Continue to seek funding for tour loop and parking lot repair.

64. Evaluate the need for new overlooks, photo blinds, and parking areas along refuge roads and trails. Initiate necessary improvements.

7.3 Cameron County District Strategies

1. Restore and manage wetlands in the following tracts in this management district: Ranchito (#54), 8 wetlands totaling 170 acres (priority 5 of 11); La Selva Verde (#78), 6 wetlands totaling 397 acres (priority 6 of 11); Resaca del Rancho Viejo (#49), 1 wetland totaling 25 acres, (priority 7 of 11); La Gloria (#82), 1 wetland totaling 20 acres, (priority 8 of 11); Tahuachal Banco (#69), 1 wetland totaling 20 acres, (priority 10 of 11).

2. Locate county roads adjacent to refuge tracts that would allow for the development of interpretive pull-offs, such as the Resaca del Rancho Viejo Tract (#49) which as a county road goes through it. Provide interpretive panels, signs, and brochures relating wildlife benefits provided by restored wetlands.

3. Continue to revegetate cropland in proportion to total farm acreage managed by the refuge in Cameron County. In September, 1997, 3,157.7 acres of refuge cropland were covered under Cooperative Farming agreements in Cameron County; this represents 30% of the total refuge Cooperative Farming acreage of 10,370.7 acres. Revegetation will be completed on 435.3 acres in Cameron County by February, 1998.

4. Continue wetland restoration work at La Selva Verde Tract (#78) near Laguna Atascosa NWR. Investigate and determine the grazing potential for some of the upland portions of this tract.

5. Increase monitoring of fences, signs and gates on the Loma Preserve (#62) which is leased from the Port of Brownsville.

6. Highway 4 to the Gulf should be maintained as access for traditional uses of the Playa del Rio beach areas for fishing and other recreational access. Develop a cooperative management agreement with TPWD and Cameron County for the management of the shore and beach areas and develop interpretive pull-offs from Highway 4.

7. Develop more comprehensive management plan for Playa del Rio area when acquisition is completed.

8. Establish a practical and reasonable protocol on establishing water quality before it is pumped because of salt water intrusion especially in the Boscaje Tract (#59) and Sabal Palm Grove which share a resaca.

9. Develop cooperative agreements with farmers to farm tracts prone to be fire hazards because of grasses and weeds, provide extra protection until fire danger is reduced.

10. Continue to monitor and protect threatened and endangered plant species such as *Ayenia limitaris* by placing each known plant on the GPS system coordinates.

11. Use GIS and GPS to conduct improved floristic surveys, especially on tracts subject to oil and gas exploration.

7.4 Upper Hidalgo and Willacy County District Strategies

1. Continue to revegetate cropland in proportion to total farm acreage managed by the refuge in upper Hidalgo and Willacy Counties. In September, 1997, 5,293.3 acres of refuge cropland were covered under Cooperative Farming agreements in this area; this represents 51% of the total refuge Cooperative Farming acreage of 10,370.7 acres. Revegetation will be completed on 405.4 acres in upper Hidalgo and Willacy Counties by February, 1998.

2. Continue to protect the National Historic Register District surrounding the 530 acre salt lake within the 5,384 acre La Sal del Rey Tract (#85).

3. Develop and implement grassland and savanna restoration techniques on upland sites at the La Sal del Rey Tract (#85), mainly north and west of the lake.

4. Continue wetland management projects in the Teniente Tract (#41), 17 wetland areas totaling 143 acres (priority 4 of 11). Restore wetland basins and potholes

5. Attempt to acquire mineral rights and associated leasehold rights, or develop a cooperative agreement or letter of understanding with the salt/brine extraction lease holders to minimize damages caused by extraction activities.

6. If determined compatible, establish limited public access for wildlife observation and, photography on the Sal del Rey Tract (#85) and/or the Schaleben Tract (#37).

7. Work with TPWD to evaluate deer herd population (5-year) trends in the East Lake Teniente Tract (#41). Establish a deer hunt if the trend analysis demonstrates a harvestable surplus and if the proposed activity is determined compatible in accordance with policy and law.

8. Maintain hog traps throughout Refuge Tracts.

9. Develop migratory bird food plots on some of the District's tracts adjacent to TPWD lands as a five year test project. Choose lands adjacent to brushy habitat.

10. Continue efforts to work with oil and gas developers on designing access to sites which cause the least amount of impacts to the wildlife and habitat resources.

11. Perfect water rights in the lower Rio Grande Basin and the Nueces/ Rio Grande Coastal Basin areas. Investigate rights needed to pump from Coastal Basin drainage ditches.

12. Pursue possible land exchanges involving the Monte Christo tract.

13. Develop cooperative agreements with farmers to farm tracts prone to be fire hazards because of grasses and weeds, provide extra protection until fire danger is reduced.

14. Use GIS and GPS to conduct improved floristic surveys, especially on tracts subject to oil and gas exploration.

Appendix

APPENDIX A

Butterflies of the LRGV/Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

Swallowtails Family Papilionidae

Pipevine Swallowtail	*Battus philenor*
Polydamas Swallowtail	*Battus polydamas*
Dark Kite-Swallowtail	*Eurytides philolaus*
Black Swallowtail	*Papilio polyxenes*
Thoas Swallowtail	*Papilio thoas*
Giant Swallowtail	*Papilio cresphontes*
Broad-banded Swallowtail	*Papilio astyalus*
Three-tailed Swallowtail	*Papilio pilumnus*
Ornythion Swallowtail	*Papilio ornythion*
Palamedes Swallowtail	*Papilio palamedes*
Victorine Swallowtail	*Papilio victorinus*
Ruby-spotted Swallowtail	*Papilio anchisiades*

Whites and Sulphurs Family Pieridae
Whites Subfamily Pierinae

Florida White	*Appias drusilla*
Checkered White	*Pontia protodice*
Cabbage White	*Pieris rapae*
Great Southern White	*Ascia monuste*
Giant White	*Ganyra josephina*
Falcate Orangetip	*Anthocharis midea*

Sulphurs Subfamily Coliadinae

Clouded Sulphur	*Colias philodice*
Orange Sulphur	*Colias eurytheme*
Southern Dogface	*Colias cesonia*
White Angled-Sulphur	*Anteos clorinde*
Yellow Angled-Sulphur	*Anteos maerula*
Cloudless Sulphur	*Phoebis sennae*
Orange-barred Sulphur	*Phoebis philea*
Apricot Sulphur	*Phoebis argante*
Large Orange Sulphur	*Phoebis agarithe*

Tailed Sulphur	*Phoebis neocypris*
Statira Sulphur	*Phoebis statira*
Lyside Sulphur	*Kricogonia lyside*
Barred Yellow	*Eurema daira*
Boisduval's Yellow	*Eurema boisduvaliana*
Mexican Yellow	*Eurema mexicana*
Salome Yellow	*Eurema salome*
Tailed Orange	*Eurema proterpia*
Little Yellow	*Eurema lisa*
Mimosa Yellow	*Eurema nise*
Dina Yellow	*Eurema dina*
Sleepy Orange	*Eurema nicippe*
Dainty Sulphur	*Nathalis iole*

Mimic-Whites Subfamily Dismorphiinae

Costa-spotted Mimic-White	*Enantia albania*

Gossamer-wing Butterflies Family Lycaenidae

Hairstreaks Subfamily Theclinae

Strophius Hairstreak	*Allosmaitia strophius*
Grest Purple Hairstreak	*Atlides halesus*
Gold-bordered Hairstreak	*Rekoa palegon*
Marius Hairstreak	*Rekoa marius* (=spurina)
Black Hairstreak	*Ocaria ocrisia*
Telea Hairstreak	*Chlorostrymon telea*
Silver-banded Hairstreak	*Chlorostrymon simaethis*
Clench's Greenstreak	*Cyanophrys miserabilis*
Goodson's Greenstreak	*Cyanophrys goodsoni*
Tropical Greenstreak	*Cyanophrys herodotus*
Xami Hairstreak	*Callophrys xami*
Aquamarine Hairstreak	*Oenomaus ortygnus*
Gray Hairstreak	*Strymon melinus*
Red-crescent Scrub-Hairstreak	*Strymon rufofusca*
Red-lined Scrub-Hairstreak	*Strymon bebrycia*
Yojoa Scrub-Hairstreak	*Strymon yojoa*
White Scrub-Hairstreak	*Strymon albata*
Lacey's Scrub-Hairstreak	*Strymon alea*
Tailless Scrub-Hairstreak	*Strymon cestri*
Lantana Scrub-Hairstreak	*Strymon bazochii*
Ruddy Hairstreak	*Electrostrymon sangala* (=cyphara)
Dusky-blue Groundstreak	*Calycopis isobeon*
Red-spotted Hairstreak	*Tmolus echion*

Clytie Ministreak	*Ministrymon clytie*
Gray Ministreak	*Ministrymon azia*

Blues Subfamily Polyommatinae

Western Pygmy-Blue	*Brephidium exilis*
Cassius Blue	*Leptotes cassius*
Marine Blue	*Leptotes marina*
Cyna Blue	*Zizula cyna*
Ceraunus Blue	*Hemiargus ceraunus*
Reakirt's Blue	*Hemiargus isola*
Eastern Tailed-Blue	*Everes comyntas*

Metalmarks Family Riodinidae

Fatal Metalmark	*Calephelis nemesis*
Rounded Metalmark	*Calephelis nilus*
Red-bordered Metalmark	*Caria ino*
Blue Metalmark	*Lasaia sula*
Red-bordered Pixie	*Melanis pixie*
Curve-winged Metalmark	*Emesis emesis*
Narrow-winged Metalmark	*Apodemia multiplaga*
Walker's Metalmark	*Apodemia walkeri*

Brush-footed Butterflies Family Nymphalidae
Snouts Subfamily Libytheinae

American Snout	*Libytheana carinenta* (includes bachmanni and motya)

Heliconians and Fritillaries Subfamily Heliconiinae

Gulf Fritillary	*Agraulis vanillae*
Mexican Silverspot	*Dione moneta*
Banded Orange Heliconian	*Dryadula phaetusa*
Julia	*Dryas Iulia*
Isabella's Heliconian	*Eueides isabella*
Zebra	*Heliconius charitonia*
Erato Heliconian	*Heliconius erato*
Variegated Fritillary	*Euptoieta claudia*

Mexican Fritillary	*Euptoieta hegesia*

True Brush-foots Subfamily Nymphalinae

Theona Checkerspot	*Thessalia theona*
Bordered Patch	*Chlosyne lacinia*
Definite Patch	*Chlosyne definita*
Banded Patch	*Chlosyne endeis*
Crimson Patch	*Chlosyne janais*
Rosita Patch	*Chlosyne rosita*
Red-spotted Patch	*Chlosyne marina*
Elf	*Microtia elva*
Tiny Checkerspot	*Dymasia dymas*
Elada Checkerspot	*Texola elada*
Texan Crescent	*Phyciodes texana*
Cuban Crescent	*Phyciodes frisia*
Black Crescent	*Phyciodes ptolyca*
Vesta Crescent	*Phyciodes vesta*
Phaon Crescent	*Phyciodes phaon*
Pearl Crescent	*Phyciodes tharos*
Question Mark	*Polygonia interrogationis*
Mourning Cloak	*Nymphalis antiopa*
American Lady	*Vanessa virginiensis*
Painted Lady	*Vanessa cardui*
Red Admiral	*Vanessa atalanta*
Common Buckeye	*Junonia coenia*
Mangrove Buckeye	*Junonia evarate*
White Peacock	*Anartia jatrophae*
Banded Peacock	*Anartia fatima*
Malachite	*Siproeta stelenes*

Admirals and Relatives Subfamily Limenitidinae

Viceroy	*Limenitis archippus*
Band-celled Sister	*Adelpha fessonia*
Common Banner	*Epiphile adrasta*
Mexican Bluewing	*Myscelia ethusa*
Blackened Bluewing	*Myscelia cyananthe*
Dingy Purplewing	*Eunica monima*
Florida Purplewing	*Eunica tatila*
Blue-eyed Sailor	*Dynamine dyonis*
Mexican Eighty-eight	*Diaethria asteria*

Common Mestra	*Mestra amymone*
Red Rim	*Biblis hyperia*
Red Cracker	*Hamadryas amphinome*
Gray Cracker	*Hamadryas februa*
Variable Cracker	*Hamadryas feronia*
Guatemalan Cracker	*Hamadryas guatemalena*
Karwinski's Beauty	*Smyrna karwinskii*
Waiter Daggerwing	*Marpesia zerynthia* (=coresia)
Many-banded Daggerwing	*Marpesia chiron*
Ruddy Daggerwing	*Marpesia petreus*

Leafwings Subfamily Charaxinae

Tropical Leafwing	*Anaea aidea*
Goatweed Leafwing	*Anaea andria*
Angled Leafwing	*Anaea glycerium*
Pale-spotted Leafwing	*Anaea pithyusa*

Emperors Subfamily Apaturinae

Hackberry Emperor	*Asterocampa celtis*
Empress Leilia	*Asterocampa leilia*
Tawny Emperor	*Asterocampa cyton*
Pavon Emperor	*Doxocopa pavon*
Silver Emperor	*Doxocopa laure*

Satyrs Subfamily Satyrinae

Gemmed Satyr	*Cyllopsis gemma*
Carolina Satyr	*Hermeuptychia sosybius*

Monarchs Subfamily Danainae

Monarch	*Danaus Plexippus*
Queen	*Danaus Gilippus*
Soldier	*Danaus Eresimus*

Skippers Family Hesperiidae

Spread-wing Skippers Subfamily Pyrginae

Guava Skipper	*Phocides palemon* (=polybius)
Mercurial Skipper	*Proteides mercurius*
Broken Silverdrop	*Epargyreus exadeus*

Hammock Skipper	*Polygonus leo*
White-striped Longtail	*Chioides catillus*
Zilpa Longtail	*Chioides zilpa*
Golden-spotted Aguna	*Aguna asander*
Emerald Aguna	*Aguna claxon*
Tailed Aguna	*Aguna metophis*
Mexican Longtail	*Polythrix mexicana*
Eight-spotted Longtail	*Polythrix octomaculata*
White-crescent Longtail	*Codatractus alcaeus*
Long-tailed Skipper	*Urbanus proteus*
Pronus Longtail	*Urbanus pronus*
Esmeraldus Longtail	*Urbanus esmeraldus*
Dorantes Longtail	*Urbanus dorantes*
Teleus Longtail	*Urbanus teleus*
Tanna Longtail	*Urbanus tanna*
Plain Longtail	*Urbanus simplicius*
Brown Longtail	*Urbanus procne*
White-tailed Longtail	*Urbanus doryssus*
Two-barred Flasher	*Astrapes fulgerator*
Small-spotted Flasher	*Astrapes egregius*
Frosted Flasher	*Astrapes alardus*
Gilbert's Flasher	*Astrapes gilberti*
Yellow-tipped Flasher	*Astrapes anaphus*
Coyote Cloudywing	*Achalarus toxeus*
Skinner's Cloudywing	*Achalarus albociliatus*
Jalapus Cloudywing	*Achalarus jalapus*
Potrillo Skipper	*Cabares potrillo*
Fritzgaetner's Flat	*Celaenorrhinus fritzgaetneri*
Stallings' Flat	*Celaenorrhinus stallingsi*
Falcate Skipper	*Spathilepia clonius*
Mimosa Skipper	*Cogia calchas*
Acacia Skipper	*Cogia hippalus*
Purplish-black Skipper	*Nisoniades rubescens*
Glazed Pellicia	*Pellicia arina*
Mottled Bolla	*Bolla clytius*
Obscure Skipper	*Bolla brennus*
Golden-headed Scallopwing	*Staphylus ceos*
Mazans Scallopwing	*Staphylus mazans*
Variegated Skipper	*Gorgythion begga*
Blue-studded Skipper	*Sostrata bifasciata*
Hoary Skipper	*Carrhenes canescens*
Glassy-winged Skipper	*Xenophanes tryxus*
Sickle-winged Skipper	*Achlyodes mithridates* (=thraso)

Hermit Skipper	*Grais stigmatica*
Brown-banded Skipper	*Timochares ruptifasciatus*
White-patched Skipper	*Chiomara asychis*
False Duskywing	*Gesta gesta*
Zarucco Duskywing	*Erynnis zarucco*
Common Checkered-Skipper	*Pyrgus communis*
Tropical Checkered-Skipper	*Pyrgus oileus*
Desert Checkered-Skipper	*Pyrgus philetas*
Erichson's White-Skipper	*Heliopetes domicella*
Laviana White-Skipper	*Heliopetes laviana*
Turk's-cap White-Skipper	*Heliopetes macaira*
Veined White-Skipper	*Heliopetes arsalte*
Common Streaky-Skipper	*Celotes nessus*
Common Sootywing	*Pholisora catullus*

Grass Skippers Subfamily Hesperiinae

Small-spotted Skipperling	*Piruna microsticta*
Malicious Skipper	*Synapte malitiosa*
Salenus Skipper	*Synapte salenus*
Redundant Skipper	*Corticea corticea*
Pale-rayed Skipper	*Vidius perigenes*
Violet-patched Skipper	*Monca telata*
Julia's Skipper	*Nastra julia*
Fawn-spotted Skipper	*Cymaenes odilia*
Clouded Skipper	*Lerema accius*
Green-backed Ruby-eye	*Perichares philetes*
Osca Skipper	*Rhinthon osca*
Double-dotted Skipper	*Decinea percosius*
Hidden-ray Skipper	*Conga chydaea*
Least Skipper	*Ancyloxpha numitor*
Tropical Least Skipper	*Ancyloxpha arena*
Orange Skipperling	*Copaeodes aurantiacus*
Southern Skipperling	*Copaeodes minimus*
Fiery Skipperling	*Hylephila phyleus*
Whirlabout	*Polites vibex*
Southern Broken-Dash	*Wallengrenia otho*
Sachem	*Atalopedes campestris*
Delaware Skipper	*Atrytone logan*
Eulogius Skipper	*Mellana eulogius*
Dun Skipper	*Euphyes vestris*
Nysa Roadside-Skipper	*Amblyscirtes nysa*
Celia's Roadside-Skipper	*Amblyscirtes celia*

Eufala Skipper	*Lerodea eufala*
Violet-clouded Skipper	*Lerodea arabus*
Brazilian Skipper	*Calpodes ethlius*
Ocola Skipper	*Panoquina ocola*
Hecebolus Skipper	*Panoquina hecebola*
Purple-washed Skipper	*Panoquina sylvicola*
Evan's Skipper	*Panoquina fusina*
Violet-banded Skipper	*Nyctelius nyctelius*
Chestnut-marked Skipper	*Thespieus macareus*

Giant-Skippers Subfamily Megathyminae

Yucca Giant-Skipper	*Megathymus yuccae*
Manfreda Giant-Skipper	*Stallingsia maculosa*

APPENDIX B

Fishes of the LRGV/Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

MUGILIDAE	
Striped Mullet	*Mugil cephalus*
ANGUILLIDAE	
American Eel	*Anguilla rostrata*
LEPISOSTEIDAE	
Alligator Gar	*Atractosteus spatula*
Longnose Gar	*Lepisosteus osseus*
Spotted Gar	*Lepisosteus oculatus*
CHARACIDAE	
Mexican Tetra	*Astyanax mexicanus*
ICTALURIDAE	
Channel Catfish	*Ictalurus punctatus*
CLUPEIDAE	
Gizzard Shad	*Dorosoma cepedianum*
Threadfin Shad	*Dorosoma peteneuse*
CYPRINIDAE	
Red Shiner	*Cyprinella lutrensis*
Common Carp	*Cypinus carpis*
Buffalofish	*Ictiobus bubalus*
BELONIDAE	
Atlantic Needlefish	*Strongylura marina*
CYPRINODONTIDAE	
Gulf Killifish	*Fundulis grandis*
Variegated Pupfish	*Cyprinodon variegatus*
Black-spotted Topminnow	*Fundulis olivarus*
Rainwater Killifish	*Lucania parva*

POECILIIDAE	
Mosquitofish	*Gambusia affinis*
Sailfin Molly	*Poecilia latipinna*
ATHERINIDAE	
Inland Silverside	*Menidia beryllina*
CICHLIDAE	
Rio Grande Cichlid	*Cichlasoma cyanoguttatum*
Blue Tilapia	*Tilapia aurea*
SCIAENIDAE	
Freshwater Drum	*Aplodinotus grunniens*
ELEOTRIDAE	
Fat Sleeper	*Dormitator maculatus*
PERCICHTHYDIDAE	
White Bass	*Morone chrysops*
CENTRARCHIDAE	
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*
Black Crappie	*Pomoxis nigromaculatis*
White Crappie	*Pomoxis annularis*

APPENDIX C

Amphibians of LRGV NWR / Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

SIRENIDAE	
Rio Grande Lesser Siren	*Siren intermedia texana*
AMBYSTOMATIDAE	
Barred Tiger Salamander	*Ambystoma tigrinum mavortium*
SALAMANDRIDAE	
Black-spotted Newt	*Notophthalmus meridionalis*
PELOBATIDAE	
Plains Spadefoot	*Scaphiopus bombifrons*
Couch's Spadefoot	*Scaphiopus couchi*
LEPTODACTYLIDAE	
Rio Grande Chirping Frog	*Syrrhophus cystignathoides campi*
HYLIDAE	
Spotted Chorus Frog	*Pseudacris clarki*
Mexican Treefrog	*Smilisca baudinii*
BUFONIDAE	
Eastern Green Toad	*Bufo debilis debilis*
Giant Toad	*Bufo marinus*
Texas Toad	*Bufo speciosus*
Gulf Coast Toad	*Bufo valliceps valliceps*
RANIDAE	
Rio Grande Leopard Frog	*Rana berlandieri*
Bullfrog	*Rana catesbeiana*
MICROHYLIDAE	
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*
Sheep Frog	*Hypopachus variolosus*

APPENDIX D

APPENDIX D

Reptiles of LRGV NWR / Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

ALLIGATORIDAE	
American Alligator	*Alligator mississippiensis*
EMYDIDAE	
Red-eared Slider	*Chrysemys scripta elegans*
TRIONYCHIDAE	
Texas Spiny Softshell	*Apalone spinifera emoryi*
TESTUDINIDAE	
Texas Tortoise	*Gopherus berlandieri*
KINOSTERNIDAE	
Yellow Mud Turtle	*Kinosternon flavescens flavescens*
POLYCHRIDAE	
Green Anole	*Anolis carolinensis*
TEIIDAE	
Texas Spotted Whiptail	*Cnemidophorus gularis gularis*
Laredo Striped Whiptail	*Cnemidophorus laredoensis*
Prairie Racerunner	*Cnemidophorus sexlineatus viridis*
GEKKONIDAE	
Texas Banded Gecko	*Coleonyx brevis*
PHRYNOSOMATIDAE	
Texas Earless Lizard	*Cophosaurus texanus texanus*
Keeled Earless Lizard	*Holbrookia popinqua popinqua*
Texas Horned Lizard	*Phrynosoma cornutum*
Mesquite Lizard	*Sceloporus grammicus*
Texas Spiny Lizard	*Sceloporus olivaceus*
Blue Spiny	*Sceloporus cyanogenys*
Southern Prairie Lizard	*Sceloporus undulatus consobrinus*
Rosebelly Lizard	*Sceloporus variabilis marmoratus*
CROTAPHYTIDAE	
Reticulate Collared Lizard	*Crotaphytus reticulatus*
SCINCIDAE	
Great Plains Skink	*Eumeces obsoletus*
Four-lined Skink	*Eumeces tetragrammus tetragrammus*

Ground Skink	*Scincella lateralis*
EUBLEPHARIDAE	
Mediterranean Gecko	*Hemidactylus turcicus*
LEPTOTYPHLOPIDAE	
Plains Blind Snake	*Leptotyphlops dulcis dulcis*
COLUBRIDAE	
Texas Glossy Snake	*Arizona elegans arenicola*
Mexican Racer	*Coluber constrictor oaxaca*
Black-Striped Snake	*Coniophanes imperialis imperialis*
Texas Indigo Snake	*Drymarchon corais erebennus*
Speckled Racer	*Drymobius m. margaritiferus*
Great Plains Rat Snake	*Elaphe guttata emoryi*
Mexican Hooknose Snake	*Ficimia streckeri*
Mexican Hognose Snake	*Heterodon nasicus kennerlyi*
Texas Night Snake	*Hypsiglena torquata jani*
Desert Kingsnake	*Lampropeltis getulus splendida*
Desert Kingsnake	*Lampropeltis getula splendida*
Mexican Milk Snake	*Lampropeltis triangulum annulata*
Western Coachwhip	*Mastecophis flagellum testaceus*
Striped Whipsnake	*Masticophis taeniatus*
Diamondback Water Snake	*Nerodia rhombifer rhombifer*
Rough Green Snake	*Opheodrys aestivus*
Bullsnake	*Pituophis catenifer sayi*
Texas Longnose Snake	*Rhinocheilus lecontei tessellatus*
Texas Patchnose Snake	*Salvadora grahamiae lineata*
Texas Brown Snake	*Storeria dekayi texana*
Plains Blackhead Snake	*Tantilla nigriceps*
Checkered Garter Snake	*Thamnophis marcianus marcianus*
Western Ribbon Snake	*Thamnophis proximus*
ELAPIDAE	
Texas Coral Snake	*Micrurus fulvius tener*
VIPERIDAE	
Western Diamondback Rattlesnake	*Crotalus atrox*

Number of reptile species = 49

APPENDIX E

Birds of the LRGV/ Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

GAVIIDAE	
Common Loon	*Gavia immer*
PODICIPEDIDAE	
Least Grebe	*Tachybaptus dominicus*
Pied-billed Grebe	*Podilymbus podiceps*
Horned Grebe	*Podiceps auritus*
Eared Grebe	*Podiceps nigricollis*
PELECANIDAE	
American White Pelican	*Pelecanus erythrorhynchos*
Brown Pelican	*Pelecanus occidentalis*
PHALACROCORACIDAE	
Double-crested Cormorant	*Phalacrocorax auritus*
Neotropic Cormorant	*Phalacrocorax olivaceus*
ANHINGIDAE	
Anhinga	*Anhinga anhinga*
FREGATIDAE	
Magnificent Frigatebird	*Fregata magnificens*
ARDEIDAE	
American Bittern	*Botaurus lentiginosus*
Least Bittern	*Ixobrychus exilis*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Little Blue Heron	*Egretta caerulea*
Tricolored Heron	*Egretta tricolor*
Reddish Egret	*Egretta rufescens*
Cattle Egret	*Bubulcus ibis*
Green Heron	*Butorides striatus*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Yellow-crowned Night-Heron	*Nycticorax violacea*
THRESKIORNITHIDAE	
White Ibis	*Eudocimus albus*
Glossy Ibis	*Plegadis falcinellus*
White-faced Ibis	*Plegadis chihi*
Roseate Spoonbill	*Ajaia ajaja*

CICONIIDAE	
Wood Stork	*Mycteria americana*
CATHARTIDAE	
Black Vulture	*Coragyps atratus*
Turkey Vulture	*Cathartes aura*
ANATIDAE	
Fulvous Whistling-Duck	*Dendrocygna bicolor*
Black-bellied Whistling-Duck	*Dendrocygna autumnalis*
Tundra Swan	*Cygnus columbianus*
Trumpeter Swan	*Cygnus buccinator*
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Muscovy Duck	*Cairina moschata*
Wood Duck	*Aix sponsa*
Green-winged Teal	*Anas crecca*
American Black Duck	*Anas rubripes*
Mottled Duck	*Anas fulvigula*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala ciangula*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Masked Duck	*Nomonyx dominicus*
Ruddy Duck	*Oxyura jamaicensis*
ACCIPITRIDAE	
Osprey	*Pandion haliaetus*
Hook-billed Kite	*Chondrohierax uncinatus*
Swallow-tailed Kite	*Elanoides forficatus*
White-tailed Kite	*Elanus caeruleus*
Mississippi Kite	*Ictinia mississippiensis*
Bald Eagle	*Haliaeetus leucocephalus*
Crane Hawk	*Geranospiza caerulescens*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*

Northern Goshawk	*Accipiter gentilis*
Common Black Hawk	*Buteogallus anthracinus*
Harris' Hawk	*Parabuteo unicinctus*
Gray Hawk	*Buteo nitidus*
Roadside Hawk	*Buteo magnirostris*
Red-shouldered Hawk	*Buteo lineatus*
Broad-winged Hawk	*Buteo platypterus*
Swainson's Hawk	*Buteo swainsoni*
White-tailed Hawk	*Buteo albicaudatus*
Zone-tailed Hawk	*Buteo albonotatus*
ACCIPITIDRAE	
Short-tailed Hawk	*Buteo brachyurus*
ACCIPITRIDAE	
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
FALCONIDAE	
Crested Caracara	*Caracara plancus*
Collared Forest Falcon	*Micrastur semitorquatus*
American Kestre	*Falco sparverius*
Merlin	*Falco columbarius*
Aplomado Falcon	*Falco femoralis*
Peregrine Falcon	*Falco peregrinus*
Prairie Falcon	*Falco mexicanus*
CRACIDAE	
Plain Chachalaca	*Ortalis vetula*
PHASIANIDAE	
Wild Turkey	*Meleagris gallopavo*
Northern Bobwhite	*Colinus virginianus*
Scaled Quail	*Callipepla squamata*
RALLIDAE	
Yellow Rail	*Coturnicops noveboracensis*
Clapper Rail	*Rallus longirostris*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
Purple Gallinule	*Porphyrula martinica*
Common Moorhen	*Gallinula chloropus*
American Coot	*Fulica americana*
Caribbean Coot	*Fulica caribaea*
GRUIDAE	
Sandhill Crane	*Grus canadensis*

CHARADRIIDAE	
Black-bellied Plover	*Pluvialis squatarola*
American Golden-Plover	*Pluvialis dominica*
Snowy Plover	*Charadrius alexandrinus*
Wilson's Plover	*Charadrius wilsonia*
Semipalmated Plover	*Charadrius semipalmatus*
Piping Plover	*Charadrius melodus*
Killdeer	*Charadrius vociferus*
Mountain Plover	*Charadrius montanus*
HAEMATOPODIDAE	
American Oystercatcher	*Haematopus palliatus*
RECURVIROSTRIDAE	
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
JACANIDAE	
Northern Jacana	*Jacana spinosa*
SCOLOPACIDAE	
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary Sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Spotted Sandpiper	*Actitis macularia*
Upland Sandpiper	*Bartramia longicauda*
Whimbrel	*Numenius phaeopus*
Long-billed Curlew	*Numenius americanus*
Hudsonian Godwit	*Limosa haemastica*
Marbled Godwit	*Limosa fedoa*
Ruddy Turnstone	*Arenaria interpres*
Red Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
White-rumped Sandpiper	*Calidris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Stilt Sandpiper	*Calidris himantopus*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Common Snipe	*Gallinago gallinago*
American Woodcock	*Scolopax minor*
Wilson's Phalarope	*Phalaropus tricolor*

LARIDAE	
Laughing Gull	*Larus atricilla*
Franklin's Gull	*Larus pipixcan*
Bonaparte's Gull	*Larus philadelphia*
Ring-billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*
Gull-billed Tern	*Sterna nilotica*
Caspian Tern	*Sterna caspia*
Royal Tern	*Sterna maxima*
Sandwich Tern	*Sterna sandvicensis*
Common Tern	*Sterna hirundo*
Forster's Tern	*Sterna forsteri*
Least Tern	*Sterna antillarum*
Sooty Tern	*Sterna fuscata*
Black Tern	*Chlidonias niger*
	Rynchops niger
COLUMBIDAE	
Rock Dove	*Columba livia*
Red-billed Pigeon	*Columba flavirostris*
White-winged Dove	*Zenaida asiatica*
Mourning Dove	*Zenaida macroura*
Inca Dove	*Columbina inca*
Common Ground-dove	*Columbina passerina*
Ruddy Ground-dove	*Columbina talpacoti*
White-tipped Dove	*Leptotila verreauxi*
PSITTACIDAE	
Military Macaw	*Ara militaris*
Budgerigar	*Melopsittacus undulatus*
Green Parakeet	*Aratinga holochlora*
Canary-winged Parakeet	*Brotogeris versicolurus*
Red-crowned Parrot	*Amazona viridigenalis*
Red-lored Parrot	*Amazona autumnalis*
Yellow-headed Parrot	*Amazona ochrocephala*
CUCULIDAE	
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Yellow-billed Cuckoo	*Coccyzus americanus*
Mangrove Cuckoo	*Coccyzus minor*
Greater Roadrunner	*Geococcyx californianus*
Groove-billed Ani	*Crotophaga sulcirostris*
TYTONIDAE	
Barn Owl	*Tyto alba*
STRIGIDAE	
Eastern Screech-Owl	*Otus asio*
Great Horned Owl	*Bubo virginianus*
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*
Elf Owl	*Micrathene whitneyi*

Burrowing Owl	*Athene cunicularia*
Barred Owl	*Strix varia*
Long-eared Owl	*Asio otus*
Short-eared Owl	*Asio flammeus*
CAPRIMULGIDAE	
Lesser Nighthawk	*Chordeiles acutipennis*
Common Nighthawk	*Chordeiles minor*
Pauraque	*Nyctidromus albicollis*
Common Poorwill	*Phalaenoptilus nuttallii*
Chuck-will's-widow	*Caprimulgus carolinensis*
Whip-poor-will	*Caprimulgus vociferus*
APODIDAE	
Chimney Swift	*Chaetura pelagica*
TROCHILIDAE	
Green Violet-ear	*Colibri thalassinus*
Green-breasted Mango	*Anthracothorax prevostii*
Broad-billed Hummingbird	*Cynanthus latirostris*
Buff-bellied Hummingbird	*Amazilia yucatanensis*
Blue-throated Hummingbird	*Lampornis clemenciae*
Ruby-throated Hummingbird	*Archilochus colubris*
Black-chinned Hummingbird	*Archilochus alexandri*
Anna's Hummingbird	*Calypte anna*
Rufous Hummingbird	*Selasphorus rufus*
White-eared Hummingbird	*Hylocharis leucotis*
TROGONIDAE	
Elegant Trogon	*Trogon elegans*
ALCEDINIDAE	
Ringed Kingfisher	*Ceryle torquata*
Belted Kingfisher	*Ceryle alcyon*
Green Kingfisher	*Chloroceryle americana*
PICIDAE	
Golden-fronted Woodpecker	*Melanerpes aurifrons*
Red-bellied Woodpecker	*Melanerpes carolinus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Ladder-backed Woodpecker	*Picoides scalaris*
Northern Flicker	*Colaptes auratus*
TYRANNIDAE	
Northern Beardless-Tyrannulet	*Camptostoma imberbe*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*Contopus sordidulus*
Eastern Wood-Pewee	*Contopus virens*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Acadian Flycatcher	*Empidonax virescens*

Alder Flycatcher	*Empidonax alnorum*
Willow Flycatcher	*Empidonax traillii*
Least Flycatcher	*Empidonax minimus*
Empidonax Flycatcher	*Empidonax sp.*
Black Phoebe	*Sayornis nigricans*
Eastern Phoebe	*Sayornis phoebe*
Say's Phoebe	*Sayornis saya*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Great Crested Flycatcher	*Myiarchus crinitus*
Brown-crested Flycatcher	*Myiarchus tyrannulus*
Great Kiskadee	*Pitangus sulphuratus*
Tropical Kingbird	*Tyrannus melancholicus*
Couch's Kingbird	*Tyrannus couchii*
Cassin's Kingbird	*Tyrannus vociferans*
Western Kingbird	*Tyrannus verticalis*
Eastern Kingbird	*Tyrannus tyrannus*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Rose-throated Becard	*Pachyramphus agiaiae*
ALAUDIDAE	
Horned Lark	*Eremophila alpestris*
HIRUNDINIDAE	
Purple Martin	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Barn Swallow	*Hirundo rustica*
Cliff Swallow	*Petrochelidon pyrrhonota*
Cave Swallow	*Petrochelidon fulva*
CORVIDAE	
Blue Jay	*Cyanocitta cristata*
Green Jay	*Cyanocorax yncas*
Brown Jay	*Cyanocorax morio*
Tamaulipan Crow	*Corvus imparatus*
Chihuahuan Raven	*Corvus cryptoleucus*
PARIDAE	
Carolina Chickadee	*Parus carolinensis*
Tufted Titmouse	*Parus bicolor*
REMIZIDAE	
Verdin	*Auriparus flaviceps*
SITTIDAE	
Red-breasted Nuthatch	*Sitta canadensis*
CERTHIIDAE	
Brown Creeper	*Certhia americana*

TROGLODYTIDAE	
Cactus Wren	*Campylorhynchus brunneicapillus*
Rock Wren	*Salpinctes obsoletus*
Carolina Wren	*Thryothorus ludovicianus*
Bewick's Wren	*Thryomanes bewickii*
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Sedge Wren	*Cistothorus platensis*
Marsh Wren	*Cistothorus palustris*
REGULIDAE	
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
MUSCICAPIDAE	
Blue-gray Gnatcatcher	*Polioptila caerulea*
Black-tailed Gnatcatcher	*Polioptila melanura*
Eastern Bluebird	*Sialis sialis*
Western Bluebird	*Sialis mexicana*
Mountain Bluebird	*Sialis currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Veery	*Catharus fuscescens*
Gray-cheeked Thrush	*Catharus minimus*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
Wood Thrush	*Hylocichla mustelina*
Clay-colored Robin	*Turdus grayi*
Rufous-backed Robin	*Turdus rufopalliatus*
American Robin	*Turdus migratorius*
Aztec Thrush	*Ridgwayia pinicola*
MIMIDAE	
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Sage Thrasher	*Oreoscoptes montanus*
Brown Thrasher	*Toxostoma rufum*
Long-billed Thrasher	*Toxostoma longirostre*
Curve-billed Thrasher	*Toxostoma curvirostre*
STURNIDAE	
European Starling	*Sturnus vulgaris*
MOTACILLIDAE	
American Pipit	*Anthus spinoletta*
Sprague's Pipit	*Anthus spragueii*
BOMBYCILLIDAE	
Cedar Waxwing	*Bombycilla cedrorum*
PTILOGONATIDAE	
Phainopepla	*Phainopepla nitens*

LANIIDAE	
Loggerhead Shrike	*Lanius ludovicianus*
VIREONIDAE	
White-eyed Vireo	*Vireo griseus*
Bell's Vireo	*Vireo bellii*
Black-capped Vireo	*Vireo atricapillus*
Blue-Headed Vireo	*Vireo solitarius*
Yellow-throated Vireo	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
Philadilphia Vireo	*Vireo philadelphicus*
Red-eyed Vireo	*Vireo olivaceus*
Yellow-green Vireo	*Vireo olivaceus flaviventri*
EMBERIZIDAE	
Blue-winged Warbler	*Vermivora pinus*
Golden-winged Warbler	*Vermivora chrysoptera*
Tennessee Warbler	*Vermivora peregrina*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Virginia's Warbler	*Vermivora virginiae*
Northern Parula	*Parula americana*
Tropical Parula	*Parula pitiayumi*
Yellow Warbler	*Dendroica petechia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Magnolia Warbler	*Dendroica magnolia*
Black-throated Blue Warbler	*Dendroica caerulecins*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Gray Warbler	*Dendroica nigrescens*
Townsend's Warbler	*Dendroica townsendi*
Black-throated Green Warbler	*Dendroica virens*
Blackburnian Warbler	*Dendroica fusca*
Yellow-throated Warbler	*Dendroica dominica*
Pine Warbler	*Dendroica pinus*
Prairie Warbler	*Dendroica discolor*
Palm Warbler	*Dendroica palmarum*
Bay-breasted Warbler	*Dendroica castanea*
Cerulean Warbler	*Dendroica cerulea*
Black-and-White Warbler	*Mniotilta variaa*
American Redstart	*Setophaga ruticilla*
Prothonotary Warbler	*Protonotaria citrea*
Worm-eating Warbler	*Helmitheros vermivorus*
Ovenbird	*Seiurus aurocapillus*
Northern Waterthrush	*Seiurus noveboracensis*
Louisiana Waterthrush	*Seiurus motacilla*
Connecticut Warbler	*Oporornis agilis*
Mourning Warbler	*Oporornis philadelphia*
MacGillivray's Warbler	*Oporornis tolmiei*
Common Yellowthroat	*Geothlypis trichas*
Gray-crowned Yellowthroat	*Geothlypis poliocephala*
Hooded Warbler	*Wilsonia citrina*

Wilson's Warbler	*Wilsonia pusilla*
Canada Warbler	*Wilsonia canadensis*
Golden-crowned Warbler	*Basileuterus culicivorus*
Yellow-breasted Chat	*Icteria virens*
Summer Tanager	*Piranga rubra*
Scarlet Tanager	*Piranga olivacea*
Crimson-collared Grosbeak	*Rhodothraupis celaeno*
Northern Cardinal	*Cardinalis cardinalis*
Pyrrhuloxia	*Cardinalis sinuatus*
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Bunting	*Cyanocompsa parellina*
Blue Grosbeak	*Guiraca caerulea*
Lazuli Bunting	*Passerina amoena*
Indigo Bunting	*Passerina cyanea*
Varied Bunting	*Passerina versicolor*
Painted Bunting	*Passerina ciris*
Dickcissel	*Spiza americana*
Olive Sparrow	*Arremonops rufivirgatus*
Green-Tailed Towhee	*Pipilo chlorurus*
Eastern Towhee	*Pipilo erythrophthalmus*
White-collared Seedeater	*Sporophila torqueola*
Yellow-faced Grassquit	*Tiaris olivacea*
Botteri's Sparrow	*Aimophila aestivalis*
Cassin's Sparrow	*Aimophila cassinii*
Chipping Sparrow	*Spizella passerina*
Clay-colored Sparrow	*Spizella pallida*
Brewer's Sparrow	*Spizella breweri*
Field Sparrow	*Spizella pusilla*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Black-throated Sparrow	*Amphispiza bilineata*
Lark Bunting	*Calamospiza melanocorys*
Savannah Sparrow	*Passerculus sandwichensis*
Baird's Sparrow	*Ammodramus bairdii*
Grasshopper Sparrow	*Ammodramus savannarum*
LeConte's Sparrow	*Ammodramus leconteii*
Nelson's Sharp-Tailed Sparrow	*Ammodramus nelsoni*
Seaside Sparrow	*Ammodramus maritimus*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*
White-throated Sparrow	*Zonotrichia albicollis*
White-crowned Sparrow	*Zonotrichia leucophrys*
Dark-eyed Junco	*Junco hyemalis*
Smith's Longspur	*Calcarius pictus*
Red-winged Blackbird	*Agelaius phoeniceus*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

Brewer's Blackbird	*Euphagus cyanocephalus*
Great-tailed Grackle	*Quiscalus mexicanus*
Common Grackle	*Quiscalus quiscula*
Bronzed Cowbird	*Molothrus aeneus*
Brown-headed Cowbird	*Molothrus ater*
Orchard Oriole	*Icterus wagleri*
Hooded Oriole	*Icterus cucullatus*
Streak-backed Oriole	*Icterus pustulatus*
Altamira Oriole	*Icterus gularis*
Audubon's Oriole	*Icterus graduacauda*
Baltimore Oriole	*Icterus galbula*
Bullock's Oriole	*Icterus bullockii*
Scott's Oriole	*Icterus parisorum*
FRINGILLIDAE	
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus mexicanus*
Red Crossbill	*Loxia curvirostra*
Pine Siskin	*Carduelis pinus*
Lesser Goldfinch	*Carduelis psaltria*
Lawrence's Goldfinch	*Carduelis lawrencei*
American Goldfinch	*Carduelis tristis*
PASSERIDAE	
House Sparrow	*Passer domesticus*

Number of bird species = 413

APPENDIX F

Mammals of The LRGV/ Santa Ana NWR Complex

Species listed have been recorded as of August 1997. List will enlarge as biological surveys continue and new refuge tracts are added.

DIDELPHIDAE

Virginia Opossum	*Didelphis virginiana californica*

SORICIDAE

Least Shrew	*Cryptotis parva berlandieri*

PHYLLOSTOMATIDAE

Peter's Ghost-faced Bat	*Mormoops megalophylla megalophylla*

VESPERTILIONIDAE

Cave Myotis	*Myotis velifer incautus*
Eastern Pipistrelle	*Pipistrellus subflavus subflavus*
Big Brown Bat	*Eptesicus fuscus fuscus*
Evening Bat	*Nycticeius humeralis mexicanus*
Northern Yellow Bat	*Lasiurus intermedius intermedius*
Red Bat	*Lasiurus borealis borealis*
Hoary Bat	*Lasiurus cinereus cinereus*
Pallid Bat	*Antrozous pallidus obscurus*

MOLOSSIDAE

Mexican Free-tailed Bat	*Tadarida brasiliensis mexicana*

DASYPODIDAE

Nine-banded Armadillo	*Dasypus novemcinctus mexicanus*

LEPORIDAE

Eastern Cottontail	*Sylvilagus floridanus chapmani*
Black-tailed Jackrabbit	*Lepus californicus merriami*

SCIURIDAE

Mexican Ground Squirrel	*Spermophilus mexicanus parvidens*
Spotted Ground Squirrel	*Spermophilus spilosoma annectens*
*Fox Squirrel	*Sciurus niger*

HETEROMYIDAE

Silky Pocket Mouse	*Perognathus flavus merriami*
Hispid Pocket Mouse	*Chaetodipus hispidus hispidus*
Ord Kangaroo Rat	*Dipodomys ordii durranti*
South Texas Kangaroo Rat	*Dipodomys compactus*
Mexican Spiny Pocket Mouse	*Liomys irroratus texensis*
CASTORIDAE	
Beaver	*Castor canadensis mexicanus*
MURIDAE	
Coues' Rice Rat	*Oryzomys palustris couesi*
Fulvous Harvest Mouse	*Reithrodontomys fulvescus*
White-footed Mouse	*Peromyscus leucopus texanus*
Northern Pygmy Mouse	*Baiomys taylori taylori*
Northern Grasshopper Mouse	*Onychomys leucogaster longipes*
Hispid Cotton Rat	*Sigmodon hispidus berlandieri*
South Plains Wood Rat	*Neotoma micropus micropus*
*Black Rat	*Rattus rattus*
*Norway Rat	*Rattus norvegicus*
*House Mouse	*Mus musculus*
CAPROMYIDAE	
*Nutria	*Myocastor coypus*
CANIDAE	
Coyote	*Canis latrans microdon*
Gray Fox	*Urocyon cinereoargenteus scottii*
PROCYONIDAE	
Raccoon	*Procyon lotor fuscipes*
MUSTELIDAE	
Long-tailed Weasel	*Mustela frenata frenata*
Badger	*Taxidea taxus berlandieri*
Eastern Spotted Skunk	*Spilogale putorius interrupta*
Striped Skunk	*Mephitis mephitis varians*
FELIDAE	
Mountain Lion	*Felis concolor*
Ocelot	*Felis pardalis albescens*
Jaguarundi	*Felis yagouaroundi cacomitli*
Bobcat	*Felis rufus texensis*

SUIDAE

*Feral Hog	*Sus scrofa*

TAYASSUIDAE

Collared Peccary	*Dicotyles tajacu angulatus*

CERVIDAE

White-tailed Deer	*Odocoileus virginianus texanus*

BOVIDAE

*Nilgai	*Boselaphus tragocamelus*

Total number of mammal species = 50

*** Indicates introduced species**

Plant Species List

Lower Rio Grande Valley NWR and Santa Ana NWR
Update: September 12, 1997

This table contains all plant species that have been reported on tracts of Lower Rio Grande Valley NWR, or on other conservation lands in the Area of Ecological Concern. A total of 776 entries are included in the table; approximately 1,200 are believed to occur in the Area of Ecological Concern. Some species have not been independantly verified. Furthermore, in cases where more than one valid taxonomic treatment exists, all synonyms are included. This is especially true in the Cactaceae, due to the taxonomic problems in that family. This table includes 31 entries in Cactaceae, which represent only 23 taxa.

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Acanthaceae	*Carlowrightia*	*parviflora*			
Acanthaceae	*Dicliptera*	*vahliana*			
Acanthaceae	*Elytraria*	*bromoides*			
Acanthaceae	*Jacobinia*	*spicigera*			
Acanthaceae	*Justicia*	*runyonii*		Runyon's Waterwillow	
Acanthaceae	*Ruellia*	*corzoi*			
Acanthaceae	*Ruellia*	*occidentalis*		Wild Petunia	
Acanthaceae	*Ruellia*	*runyonii*		Runyon's Ruellia	
Acanthaceae	*Siphonoglossa*	*greggii*			
Acanthaceae	*Siphonoglossa*	*pilosella*		Hairy Tube-Tongue	
Acanthaceae	*Stenandrium*	*dulce*			
Acanthaceae	*Stenandrium*	*floridanum*		Sweet Stenandrium	
Aizoaceae	*Glinus*	*lotoides*			
Aizoaceae	*Glinus*	*radiatus*			
Aizoaceae	*Sesuvium*	*erectum*		Sea Purslane	
Aizoaceae	*Sesuvium*	*portulacastrum*			
Aizoaceae	*Sesuvium*	*sessile*			
Aizoaceae	*Trianthema*	*portulacastrum*			
Alismataceae	*Echinodorus*	*cordifolius*			
Alismataceae	*Echinodorus*	*rostratus*			
Alismataceae	*Sagittaria*	*longiloba*			
Amaranthaceae	*Achyranthes*	*aspera*			
Amaranthaceae	*Alternanthera*	*caracasana*		Mat Chaff-flower	Verdolaga de Puerco
Amaranthaceae	*Amaranthus*	*berlandieri*			
Amaranthaceae	*Amaranthus*	*palmeri*			
Amaranthaceae	*Amaranthus*	*scleropoides*			
Amaranthaceae	*Celosia*	*nitida*			Albahaca
Amaranthaceae	*Froelichia*	*gracilis*		Snake-cotton	
Amaranthaceae	*Gossypianthus*	*lanuginosus*		Cotton Flower	
Amaranthaceae	*Iresine*	*palmeri*			
Amaranthaceae	*Tidestromia*	*lanuginosa*			Espanta Vaqueros
Amaryllidaceae	*Agave*	*americana*		Century Plant	Maguey
Amaryllidaceae	*Agave*	*lecheguilla*			Lechuguilla

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Amaryllidaceae	*Agave*	*lophantha*		Thorn-crested Agave	
Amaryllidaceae	*Agave*	*scabra*			
Amaryllidaceae	*Aloe*	*barbadensis*		Aloe Vera	Sábila
Amaryllidaceae	*Cooperia*	*drummondii*		Showy Zephyr-lily	Cebolleta
Amaryllidaceae	*Manfreda*	*longiflora*		Runyon's Huaco	Huaco
Amaryllidaceae	*Manfreda*	*sileri*			
Amaryllidaceae	*Manfreda*	*variegata*		Texas Tuberose	Huaco
Amaryllidaceae	*Zephyranthes*	*brazosensis*		Showy Zephyr-Lily	Cebolleta
Amaryllidaceae	*Zephyranthes*	*pulchella*			
Anacardiaceae	*Schinus*	*longifolius*			
Anacardiaceae	*Schinus*	*molle*			
Anacardiaceae	*Schinus*	*terrebinthefolius*		Brazilian Pepper	
Apiaceae	*Ammoselinum*	*popei*			
Apiaceae	*Bowlesia*	*incana*			
Apiaceae	*Ciclospermum*	*leptophyllum*		Slimlobe Celery	
Apiaceae	*Daucus*	*pusillus*			
Apiaceae	*Eryngium*	*nasturtiifolium*			
Apiaceae	*Hydrocotyle*	*bonariensis*			
Apocynaceae	*Macrosiphonia*	*macrosiphon*		Rock Trumpet	Flor de San Juan
Apocynaceae	*Macrosiphonia*	*lanuginosa*	macrosiphon	Rock Trumpet	Flor de San Juan
Apocynaceae	*Nerium*	*oleander*		Common Oleander	
Arecaceae	*Sabal*	*mexicana*		Texas Sabal Palm	Palma Sabal
Arecaceae	*Sabal*	*texana*		Texas Sabal Palm	Palma Sabal
Arecaceae	*Washingtonia*	*filifera*		Washington Palm	
Arecaceae	*Washingtonia*	*robusta*		Washington Palm	
Aristolochiaceae	*Aristolochia*	*pentandra*			
Asclepiadaceae	*Asclepias*	*curassavica*			
Asclepiadaceae	*Asclepias*	*linearis*			
Asclepiadaceae	*Cynanchum*	*barbigerum*			
Asclepiadaceae	*Cynanchum*	*laeve*		Blue-vine, Sand-vine	
Asclepiadaceae	*Matelea*	*reticulata*		Reticulated Milkvine	
Asclepiadaceae	*Matelea*	*sagittifolia*			
Asclepiadaceae	*Matelea*	*woodsonii*			
Asclepiadaceae	*Periploca*	*graeca*			
Asclepiadaceae	*Sarcostemma*	*cynanchoides*		Twinevine	
Asteraceae	*Acourtia*	*runcinata*		Peonia	Peonia
Asteraceae	*Ambrosia*	*confertiflora*			
Asteraceae	*Ambrosia*	*psilostachya*		Western Ragweed	
Asteraceae	*Ambrosia*	*trifida*		Giant Ragweed	
Asteraceae	*Aphanostephus*	*kidderi*		Lazy Daisy	
Asteraceae	*Aphanostephus*	*skirrhobasis*	ramosissimus		
Asteraceae	*Aphanostephus*	*skirrhobasis*		Lazy Daisy	
Asteraceae	*Aster*	*subulatus*		Saltmarsh Aster	
Asteraceae	*Baccharis*	*neglecta*		False Willow	Jarilla

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Asteraceae	*Baccharis*	*salicifolia*		Seepwillow	Jara
Asteraceae	*Baccharis*	*salicina*	neglecta	False Willow	Jara Dulce
Asteraceae	*Baccharis*	*salicina*		Seep Willow	Jara
Asteraceae	*Baccharis*	*texana*			
Asteraceae	*Bahia*	*absinthifolia*			
Asteraceae	*Bahia*	*pedata*			
Asteraceae	*Borrichia*	*frutescens*		Sea Ox-Eye	
Asteraceae	*Calyptocarpus*	*vialis*			Malva del Caballo
Asteraceae	*Centaurea*	*americana*			
Asteraceae	*Chaetopappa*	*asteroides*			
Asteraceae	*Cirsium*	*texanum*		Texas Thistle	
Asteraceae	*Clappia*	*suaedifolia*			
Asteraceae	*Conyza*	*canadensis*		Horseweed	
Asteraceae	*Conyza*	*coulteri*			
Asteraceae	*Coreopsis*	*tinctoria*		Tickseed	
Asteraceae	*Coreopsis*	*tinctoria*	cardaminifolia	Tickseed	
Asteraceae	*Eclipta*	*prostrata*			
Asteraceae	*Ericameria*	*austrotexana*			
Asteraceae	*Erigeron*	*ortegae*		Spiny Aster	
Asteraceae	*Erigeron*	*ortegae*	spinosus	Mexican Devil-weed	
Asteraceae	*Erigeron*	*tenellus*			
Asteraceae	*Eupatorium*	*azureum*		Blue Boneset	
Asteraceae	*Eupatorium*	*betonicifolium*		Betony-Leaf	
Asteraceae	*Eupatorium*	*coelestinum*		Mist-flower	
Asteraceae	*Eupatorium*	*incarnatum*			
Asteraceae	*Eupatorium*	*odoratum*			Crucita
Asteraceae	*Evax*	*verna*		Rabbit-Tobacco	
Asteraceae	*Florestina*	*tripteris*			
Asteraceae	*Gaillardia*	*pulchella*		Indian Blanket	
Asteraceae	*Gnaphalium*	*obtusifolium*		Fragrant Cudweed	
Asteraceae	*Gnaphalium*	*pensilvanicum*		Everlasting Cudweed	
Asteraceae	*Gnaphalium*	*peregrinum*		Everlasting Cudweed	
Asteraceae	*Gochnatia*	*hypoleuca*			
Asteraceae	*Gutierrezia*	*texana*			
Asteraceae	*Gymnosperma*	*glutinosum*			
Asteraceae	*Helenium*	*amarum*			
Asteraceae	*Helenium*	*amarum*	badium	Basin Sneezeweed	
Asteraceae	*Helenium*	*amphibolum*		Presidio Sneezeweed	Rosilla
Asteraceae	*Helenium*	*elegans*		Sneezeweed	
Asteraceae	*Helenium*	*quadridentatum*		Presidio Sneezeweed	Rosilla
Asteraceae	*Helianthus*	*annuus*		Common Sunflower	
Asteraceae	*Heterotheca*	*latifolia*		Camphor Weed	
Asteraceae	*Isocarpha*	*oppositifolia*			
Asteraceae	*Isocoma*	*coronopifolia*		Goldenweed	

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Asteraceae	*Isocoma*	*drummondii*			
Asteraceae	*Iva*	*annua*			
Asteraceae	*Lactuca*	*hirsuta*	albiflora		
Asteraceae	*Machaeranthera*	*phyllocephala*			
Asteraceae	*Melampodium*	*cinereum*			
Asteraceae	*Melampodium*	*cinereum*	ramosissimum		
Asteraceae	*Mikania*	*scandens*		Climbing Hemp Vine	
Asteraceae	*Palafoxia*	*rosea*			
Asteraceae	*Palafoxia*	*texana*	texana	Texas Palafoxia	
Asteraceae	*Palafoxia*	*texana*	ambigua	Texas Palafoxia	
Asteraceae	*Parthenium*	*confertum*			
Asteraceae	*Parthenium*	*hysterophorus*		False Ragweed	Cicutilla
Asteraceae	*Parthenium*	*incanum*			
Asteraceae	*Pectis*	*angustifolia*	tenella		
Asteraceae	*Pluchea*	*odorata*		Camphor Weed	
Asteraceae	*Pterocaulon*	*virgatum*			
Asteraceae	*Pyrrhopappus*	*multicaulis*			
Asteraceae	*Ratibida*	*columnaris*		Mexican Hat	
Asteraceae	*Rudbeckia*	*hirta*			
Asteraceae	*Sanvitalia*	*ocymoides*			
Asteraceae	*Sclerocarpus*	*uniserialis*		Mexican Bonebract	
Asteraceae	*Senecio*	*ampullaceus*		Texas Groundsel	
Asteraceae	*Senecio*	*tampicanus*		Groundsel	
Asteraceae	*Simsia*	*calva*			
Asteraceae	*Sonchus*	*asper*		Prickly Sowthistle	Alchicoria Dulce
Asteraceae	*Sonchus*	*oleraceus*		Common Sowthistle	
Asteraceae	*Thymophylla*	*acerosa*		Dogweed	
Asteraceae	*Thymophylla*	*aurea*			
Asteraceae	*Thymophylla*	*pentachaeta*		Dogweed	
Asteraceae	*Thymophylla*	*tenuiloba*			
Asteraceae	*Trixis*	*californica*			
Asteraceae	*Trixis*	*inula*		Mexican Trixis	
Asteraceae	*Varilla*	*texana*			Saladillo
Asteraceae	*Verbesina*	*encelioides*		Golden Crownbeard	
Asteraceae	*Verbesina*	*microptera*			Capitana
Asteraceae	*Verbesina*	*virginica*		Frostweed	
Asteraceae	*Viguiera*	*stenoloba*	chihuahuensis	Skeleton Bush	
Asteraceae	*Wedelia*	*hispida*		Orange Zexmenia	
Asteraceae	*Xanthium*	*chinense*		American Cocklebur	Abrojo
Asteraceae	*Xanthium*	*spinosum*		Cocklebur	
Asteraceae	*Xanthium*	*strumarium*		American Cocklebur	Abrojo
Asteraceae	*Zexmenia*	*brevifolia*			
Asteraceae	*Zinnia*	*acerosa*			
Basellaceae	*Anredera*	*baselloides*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Basellaceae	*Anredera*	*leptostachys*		Madeira Vine	Sacasile
Basellaceae	*Anredera*	*scandens*			
Batidaceae	*Batis*	*maritima*			
Boraginaceae	*Cordia*	*boissieri*		Wild Olive	Anacahuita
Boraginaceae	*Cryptantha*	*mexicana*			
Boraginaceae	*Ehretia*	*anacua*		Anacua	Anacua
Boraginaceae	*Heliotropium*	*angiospermum*		White Heliotrope	
Boraginaceae	*Heliotropium*	*confertifolium*			
Boraginaceae	*Heliotropium*	*curassavicum*		Seaside Heliotrope	
Boraginaceae	*Heliotropium*	*indicum*		Turnsole Heliotrope	
Boraginaceae	*Heliotropium*	*procumbens*			
Boraginaceae	*Lithospermum*	*matamorense*			
Boraginaceae	*Tiquilia*	*canescens*			Oreja de Perro
Boraginaceae	*Tiquilia*	*hispidissima*			
Brassicaceae	*Capsella*	*bursa-pastoris*			
Brassicaceae	*Descurainia*	*pinnata*			
Brassicaceae	*Iodanthus*	*pinnatifidus*		Purple Rocket	
Brassicaceae	*Lepidium*	*austrinum*			
Brassicaceae	*Lepidium*	*densiflorum*			
Brassicaceae	*Lepidium*	*lasiocarpum*			
Brassicaceae	*Lepidium*	*virginicum*		Peppergrass	Lentrilla
Brassicaceae	*Lesquerella*	*argyraea*			
Brassicaceae	*Lesquerella*	*lasiocarpa*			
Brassicaceae	*Lesquerella*	*thamnophila*		Zapata Bladderpod	
Brassicaceae	*Raphanus*	*sativus*		Radish	Rábano
Brassicaceae	*Rorippa*	*teres*		Tansyleaf Yellowcress	
Brassicaceae	*Selenia*	*grandis*			
Brassicaceae	*Sibara*	*runcinata*			
Brassicaceae	*Sisymbrium*	*irio*		London Rocket	
Bromeliaceae	*Hechtia*	*glomerata*			Guapilla
Bromeliaceae	*Tillandsia*	*baileyi*		Bailey's Ball Moss	
Bromeliaceae	*Tillandsia*	*recurvata*		Ball Moss	Gallitos
Bromeliaceae	*Tillandsia*	*usneoides*		Spanish Moss	Paxtle
Cactaceae	*Acanthocereus*	*pentagonus*		Barbed Wired Cactus	Jacobillo
Cactaceae	*Ancistrocactus*	*scheeri*		Fishhook Cactus	
Cactaceae	*Coryphantha*	*macromeris*	runyonii	Runyon's Cory Cactus	
Cactaceae	*Coryphantha*	*roberti*		Runyon's Escobaria	
Cactaceae	*Echinocactus*	*bicolor*	schottii	Glory of Texas	
Cactaceae	*Echinocactus*	*hamatacanthus*		Turk's Head	Biznaga
Cactaceae	*Echinocactus*	*scheeri*		Fishhook Cactus	
Cactaceae	*Echinocactus*	*setispinus*	hamatus	Twisted-Rib Cactus	
Cactaceae	*Echinocactus*	*setispinus*	setaceus	Hedgehog Cactus	
Cactaceae	*Echinocactus*	*sinuatus*		LRGV Barrel Cactus	
Cactaceae	*Echinocactus*	*texensis*		Horse Crippler	Manca Caballo

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Cactaceae	*Echinocereus*	*berlandieri*		Berlandier's Alicoche	
Cactaceae	*Echinocereus*	*blackii*			Alicoche
Cactaceae	*Echinocereus*	*enneacanthus*		Strawberry Cactus	Pitaya
Cactaceae	*Echinocereus*	*fitchii*		Rainbow Cactus	
Cactaceae	*Echinocereus*	*pentalophus*		Lady-Finger Alicoche	
Cactaceae	*Echinocereus*	*reichenbachii*	fitchii	Rainbow Cactus	
Cactaceae	*Lophophora*	*williamsii*			Peyote
Cactaceae	*Mammillaria*	*gummifera*		Pincushion Cactus	Pichilinga
Cactaceae	*Mammillaria*	*heyderi*		Pincushion Cactus	Pichilinga
Cactaceae	*Mammillaria*	*longimamma*	sphaerica	Pale Pincushion Cactus	
Cactaceae	*Mammillaria*	*multiceps*		Hair Covered Pincushion	
Cactaceae	*Mammillaria*	*prolifera*		Hair Covered Pincushion	
Cactaceae	*Mammillaria*	*robertii*		Runyon's Escobaria	
Cactaceae	*Mammillaria*	*runyonii*		Runyon's Cory Cactus	
Cactaceae	*Mammillaria*	*sphaerica*		Pale Pincushion Cactus	
Cactaceae	*Opuntia*	*engelmannii*		Prickly Pear	Nopal
Cactaceae	*Opuntia*	*lindheimeri*		Prickly Pear	Nopal
Cactaceae	*Opuntia*	*leptocaulis*		Pencil Cactus	Tasajillo
Cactaceae	*Opuntia*	*schottii*		Dog Cholla	Clavellina
Cactaceae	*Wilcoxia*	*poselgeri*		Pencil Cactus	Sacasil
Capparidaceae	*Capparis*	*incana*			
Capparidaceae	*Cleome*	*aculeata*		Spiderflower	
Capparidaceae	*Polanisia*	*dodecandra*			
Caryophyllaceae	*Arenaria*	*benthamii*		Sandwort	
Caryophyllaceae	*Stellaria*	*prostrata*			
Celastraceae	*Maytenus*	*phyllanthoides*			
Celastraceae	*Mortonia*	*greggii*		Gregg's Mortonia	Afinador
Celastraceae	*Schaefferia*	*cuneifolia*		Desert Yaupon	Capul
Chenopodiaceae	*Atriplex*	*acanthocarpa*		Armed Saltbush	Huaha
Chenopodiaceae	*Atriplex*	*canescens*		Four-Wing Saltbush	
Chenopodiaceae	*Atriplex*	*matamorensis*			Quelite Cenizo
Chenopodiaceae	*Atriplex*	*pentandra*			
Chenopodiaceae	*Chenopodium*	*ambrosioides*			
Chenopodiaceae	*Chenopodium*	*berlandieri*			
Chenopodiaceae	*Chenopodium*	*murale*			
Chenopodiaceae	*Salicornia*	*bigelovii*		Glasswort	Saladilla
Chenopodiaceae	*Salicornia*	*virginica*			
Chenopodiaceae	*Salsola*	*australis*		Russian Thistle	Rodeadora
Chenopodiaceae	*Salsola*	*kali*		Russian Thistle	Rodeadora
Chenopodiaceae	*Suaeda*	*conferta*		Sea Blite, Seepweed	
Chenopodiaceae	*Suaeda*	*linearis*		Sea Blite, Seepweed	
Cochlospermaceae	*Amoreuxia*	*wrightii*		Yellow-Show	
Commelinaceae	*Commelina*	*diffusa*			
Commelinaceae	*Commelina*	*elegans*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Commelinaceae	*Commelina*	*erecta*			Hierba del Pollo
Commelinaceae	*Tradescantia*	*micrantha*			
Convolvulaceae	*Convolvulus*	*equitans*		Texas Bindweed	
Convolvulaceae	*Cressa*	*nudicaulis*			
Convolvulaceae	*Cuscuta*	*indecora*			
Convolvulaceae	*Dichondra*	*carolinensis*			
Convolvulaceae	*Dichondra*	*micrantha*			
Convolvulaceae	*Evolvulus*	*alsinoides*			Ojo de Víbora
Convolvulaceae	*Evolvulus*	*sericeus*			
Convolvulaceae	*Ipomoea*	*amnicola*			
Convolvulaceae	*Iponoea*	*aristolochiifolia*	fistulosa	Tree Morning Glory	
Convolvulaceae	*Ipomoea*	*carnea*		Shrubby Morning Glory	
Convolvulaceae	*Ipomoea*	*cordatotriloba*		Tie Vine	
Convolvulaceae	*Ipomoea*	*sinuata*		Alamo Vine	Correhuela de las Doce
Crassulaceae	*Kalanchoë*	*verticillata*			
Crassulaceae	*Sedum*	*texanum*			
Cucurbitaceae	*Cucumis*	*melo*			
Cucurbitaceae	*Ibervillea*	*lindheimeri*			
Cucurbitaceae	*Ibervillea*	*tenella*		Slender Globeberry	
Cucurbitaceae	*Ibervillea*	*tripartita*		Slender Globeberry	
Cucurbitaceae	*Melothria*	*pendula*			Meloncito
Cyperaceae	*Carex*	*brittoniana*			
Cyperaceae	*Cyperus*	*aristatus*			
Cyperaceae	*Cyperus*	*articulatus*			
Cyperaceae	*Cyperus*	*erythrorhizos*			
Cyperaceae	*Cyperus*	*macrocephalus*			
Cyperaceae	*Cyperus*	*ochraceus*			
Cyperaceae	*Cyperus*	*odoratus*			
Cyperaceae	*Cyperus*	*polystachyos*	texensis		
Cyperaceae	*Cyperus*	*rotundus*			
Cyperaceae	*Cyperus*	*uniflorus*			
Cyperaceae	*Cyperus*	*virens*			
Cyperaceae	*Eleocharis*	*caribaea*			
Cyperaceae	*Eleocharis*	*macrostachya*			
Cyperaceae	*Eleocharis*	*parvula*			
Cyperaceae	*Fimbristylis*	*vahlii*			
Cyperaceae	*Scirpus*	*californicus*		Giant Bulrush	Tule
Cyperaceae	*Scirpus*	*maritimus*			
Cyperaceae	*Scirpus*	*pungens*			
Cyperaceae	*Scirpus*	*pungens*	longispicatus	Three-square Bulrush	
Cyperaceae	*Scirpus*	*supinus*			
Cyperaceae	*Scirpus*	*validus*		Soft-Stem Bulrush	Tule
Ebenaceae	*Diospyros*	*texana*		Texas Persimmon	Chapote
Elatinaceae	*Bergia*	*texana*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Ephedraceae	*Ephedra*	*antisyphilitica*		Clapweed	Popote
Ephedraceae	*Ephedra*	*pedunculata*		Vine Joint-Fir	Comida de Víbora
Euphorbiaceae	*Acalypha*	*monostachya*			
Euphorbiaceae	*Acalypha*	*poiretii*			
Euphorbiaceae	*Adelia*	*vaseyi*			
Euphorbiaceae	*Argythamnia*	*humilis*	humilis		
Euphorbiaceae	*Argythamnia*	*neomexicana*		Wild Mercury	
Euphorbiaceae	*Bernardia*	*myricifolia*			
Euphorbiaceae	*Croton*	*capitatus*		Hogwort	
Euphorbiaceae	*Croton*	*ciliatoglandulifer*		Mexican Croton	Solimán
Euphorbiaceae	*Croton*	*cortesianus*			
Euphorbiaceae	*Croton*	*glandulosus*			
Euphorbiaceae	*Croton*	*humilis*			
Euphorbiaceae	*Croton*	*incanus*			Vara Blanca
Euphorbiaceae	*Croton*	*leucophyllus*			
Euphorbiaceae	*Croton*	*lindheimerianus*			
Euphorbiaceae	*Croton*	*parksii*			
Euphorbiaceae	*Croton*	*punctatus*		Beach-tea	Hierba Del Jabalí
Euphorbiaceae	*Euphorbia*	*albomarginata*		Spurge	
Euphorbiaceae	*Euphorbia*	*cinerascens*			
Euphorbiaceae	*Euphorbia*	*cyathophora*		Painted Euphorbia	
Euphorbiaceae	*Euphorbia*	*heterophylla*			Catalina
Euphorbiaceae	*Euphorbia*	*hypericifolia*		Tropical Euphorbia	
Euphorbiaceae	*Euphorbia*	*laredana*			
Euphorbiaceae	*Euphorbia*	*maculata*		Spurge	
Euphorbiaceae	*Euphorbia*	*nutans*			
Euphorbiaceae	*Euphorbia*	*serpens*			
Euphorbiaceae	*Euphorbia*	*spathulata*			
Euphorbiaceae	*Jatropha*	*cathartica*			Jicamilla
Euphorbiaceae	*Jatropha*	*dioica*		Leather Stem	Sangre De Drago
Euphorbiaceae	*Julocroton*	*argenteus*			
Euphorbiaceae	*Manihot*	*walkerae*		Walker's Manioc	
Euphorbiaceae	*Phyllanthus*	*abnormis*			
Euphorbiaceae	*Phyllanthus*	*polygonoides*			
Euphorbiaceae	*Ricinus*	*communis*		Castor-bean	Higuerilla
Euphorbiaceae	*Sapium*	*sebiferum*		Chinese Tallow Tree	
Euphorbiaceae	*Stillingia*	*treculiana*			
Euphorbiaceae	*Tragia*	*brevispica*			
Euphorbiaceae	*Tragia*	*glanduligera*			
Fabaceae	*Acacia*	*berlandieri*			Guajillo
Fabaceae	*Acacia*	*farnesiana*		Huisache	Huizache
Fabaceae	*Acacia*	*gregii*		Gregg's Acacia	Uña de Gato
Fabaceae	*Acacia*	*rigidula*		Black Brush	Chaparro Prieto
Fabaceae	*Acacia*	*schaffneri*			Huizachillo

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Fabaceae	*Acacia*	*smallii*		Huisache	Huizache
Fabaceae	*Acacia*	*texensis*		Prairie Acacia	
Fabaceae	*Acacia*	*wrightii*		Wright's Acacia	Uña de Gato
Fabaceae	*Caesalpinia*	*mexicana*		Mexican Poinciana	Hierba del Potro
Fabaceae	*Calliandra*	*conferta*			
Fabaceae	*Cercidium*	*macrum*		Border Palo Verde	Palo Verde
Fabaceae	*Cercidium*	*texanum*		Palo Verde	Palo Verde
Fabaceae	*Clitoria*	*mariana*		Pigeon Wings	
Fabaceae	*Coursetia*	*axillaris*		Texas Baby-Bonnets	
Fabaceae	*Dalea*	*emarginata*		Wedgeleaf Prairie Clover	
Fabaceae	*Dalea*	*pogonathera*			
Fabaceae	*Dalea*	*scandens*	paucifolia	Thyrsus Dalea	
Fabaceae	*Dalea*	*thyrsiflora*		Thyrsus Dalea	
Fabaceae	*Desmanthus*	*virgatus*	depressus	Prostrate Butterfly	
Fabaceae	*Erythrina*	*herbacea*		Coral Bean	Colorín
Fabaceae	*Eysenhardtia*	*texana*		Kidney Wood	Vara Dulce
Fabaceae	*Galactia*	*canescens*			
Fabaceae	*Lespedeza*	*virginica*		Slender Bush Cover	
Fabaceae	*Leucaena*	*leucocephala*		Popinac	Guaje
Fabaceae	*Leucaena*	*pulverulenta*			Tepeguaje
Fabaceae	*Lupinus*	*subcarnosus*		Texas Bluebonnet	
Fabaceae	*Lupinus*	*texensis*		Texas Bluebonnet	
Fabaceae	*Medicago*	*polymorpha*	vulgaris	Bur-clover	
Fabaceae	*Melilotus*	*albus*		White Sweet Clover	Hubam
Fabaceae	*Mimosa*	*malacophylla*		Vine Mimosa	Raspa Huevos
Fabaceae	*Mimosa*	*pigra*	berlandieri	Black Mimosa	Coatante
Fabaceae	*Mimosa*	*strigillosa*		Powderpuff	Vergonzosa
Fabaceae	*Mimosa*	*wherryana*		Wherry Mimosa	
Fabaceae	*Parkinsonia*	*aculeata*		Retama	Retama
Fabaceae	*Pediomelum*	*rhombifolium*			
Fabaceae	*Pithecellobium*	*ebano*		Texas Ebony	Ebono
Fabaceae	*Pithecellobium*	*pallens*			Tenaza
Fabaceae	*Prosopis*	*glandulosa*		Honey Mesquite	Mezquite
Fabaceae	*Prosopis*	*reptans*	cinerascens	Dwarf Screw-Bean	Tornillo
Fabaceae	*Rhynchosia*	*minima*		Least Snoutbean	
Fabaceae	*Schrankia*	*latidens*			
Fabaceae	*Senna*	*bauhinioides*		Two-leaved Senna	
Fabaceae	*Senna*	*durangensis*	iselyi		
Fabaceae	*Senna*	*roemeriana*			
Fabaceae	*Sesbania*	*drummondii*		Rattlebush	
Fabaceae	*Sesbania*	*macrocarpa*			Bequilla
Fabaceae	*Sophora*	*secundiflora*		Mescal Bean	Frijollilo
Fabaceae	*Sophora*	*tomentosa*	occidentalis	Yellow Sophora	
Fabaceae	*Vicia*	*leavenworthii*			

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Fabaceae	*Vigna*	*luteola*			
Flacourtiaceae	*Xylosma*	*flexuosa*		Brush-Holly	Coronilla
Frankeniaceae	*Frankenia*	*johnstonii*		Johnston's Frankenia	
Gentianaceae	*Centaurium*	*calycosum*			
Gentianaceae	*Eustoma*	*exaltatum*			
Gentianaceae	*Eustoma*	*grandiflorum*		Bluebells	Lira de San Pedro
Geraniaceae	*Geranium*	*texanum*			
Hydrophyllaceae	*Nama*	*hispidum*			
Hydrophyllaceae	*Nama*	*jamaicense*			
Hydrophyllaceae	*Nama*	*stenocarpum*		Slimpod Nama	
Hydrophyllaceae	*Phacelia*	*congesta*		Blue Curls	
Hydrophyllaceae	*Phacelia*	*patuliflora*			
Juglandaceae	*Carya*	*illinoinensis*		Pecan	Nuez Encarcelada
Koeberliniaceae	*Koeberlinia*	*spinosa*		Allthorn	Junco
Krameriaceae	*Krameria*	*ramosissima*			
Lamiaceae	*Hedeoma*	*drummondii*		Pennyroyal	
Lamiaceae	*Lamium*	*amplexicaule*			
Lamiaceae	*Micromeria*	*brownei*	pilosiuscula		
Lamiaceae	*Monarda*	*citriodora*			
Lamiaceae	*Salvia*	*azurea*		Blue Sage	
Lamiaceae	*Salvia*	*ballotiflora*		Shrubby Blue Sage	Mejorana
Lamiaceae	*Salvia*	*coccinea*		Tropical Sage	
Lamiaceae	*Stachys*	*crenata*		Shade Betony	
Lamiaceae	*Stachys*	*drummondii*		Pink Mint	
Lamiaceae	*Teucrium*	*canadense*			
Lamiaceae	*Teucrium*	*cubense*		Coast Germander	
Lamiaceae	*Teucrium*	*laciniatum*		Germander	
Lemnaceae	*Lemna*	*minor*		Duckweed	
Lemnaceae	*Wolffia*	*columbiana*			
Liliaceae	*Echeandia*	*chandleri*		Chandler's Crag-Lily	Lila de los Llanos
Liliaceae	*Nothoscordum*	*bivalve*		Crow-Poison	
Liliaceae	*Smilax*	*bona-nox*		Cat-briar	Zarzaparrilla
Liliaceae	*Yucca*	*constricta*			Izote
Liliaceae	*Yucca*	*treculeana*		Spanish Dagger	Palma Pita
Loasaceae	*Cevallia*	*sinuata*		Stinging Cevallia	
Loasaceae	*Mentzelia*	*incisa*			
Loganiaceae	*Buddleja*	*sessiliflora*		Butterfly Bush	
Lythraceae	*Ammannia*	*coccinea*			
Lythraceae	*Heimia*	*salicifolia*			Hachinal
Lythraceae	*Lythrum*	*californicum*			
Malpighiaceae	*Galphimia*	*angustifolia*			
Malpighiaceae	*Malpighia*	*glabra*		Barbados Cherry	Manzanita
Malvaceae	*Abutilon*	*abutiloides*			
Malvaceae	*Abutilon*	*berlandieri*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Malvaceae	*Abutilon*	*fruticosum*			Pelotazo
Malvaceae	*Abutilon*	*hulseanum*			
Malvaceae	*Abutilon*	*hypoleucum*			
Malvaceae	*Abutilon*	*lignosum*		Indian-mallow	
Malvaceae	*Abutilon*	*trisulcatum*		Amantillo	Amantillo
Malvaceae	*Abutilon*	*umbellatum*			
Malvaceae	*Abutilon*	*wrightii*		Indian Mallow	
Malvaceae	*Allowissadula*	*holosericea*			
Malvaceae	*Allowissadula*	*lozanii*			
Malvaceae	*Anoda*	*pentaschista*			
Malvaceae	*Bastardia*	*viscosa*			
Malvaceae	*Billieturnera*	*helleri*			
Malvaceae	*Herissantia*	*crispa*			
Malvaceae	*Hibiscus*	*cardiophyllus*		Heart-Leaf Hibiscus	Tulipán del Monte
Malvaceae	*Hibiscus*	*martianus*		Heart-Leaf Hibiscus	Tulipán del Monte
Malvaceae	*Lavatera*	*trimestris*			
Malvaceae	*Malachra*	*capitata*			
Malvaceae	*Malvastrum*	*americanum*			Malva Loca
Malvaceae	*Malvastrum*	*aurantiacum*			
Malvaceae	*Malvastrum*	*coromandelianum*			
Malvaceae	*Malvaviscus*	*arboreus*	drummondii	Turk-s Cap	
Malvaceae	*Meximalva*	*filipes*			
Malvaceae	*Modiola*	*caroliniana*			
Malvaceae	*Rhynchosida*	*physocalyx*			
Malvaceae	*Sida*	*filicaulis*			
Malvaceae	*Sida*	*rhombifolia*			Axocatzin
Malvaceae	*Sida*	*spinosa*			
Malvaceae	*Sphaeralcea*	*pedatifida*			
Malvaceae	*Wissadula*	*amplissima*			
Meliaceae	*Melia*	*azedarach*		Chinaberry	Canelón
Menispermaceae	*Cocculus*	*diversifolius*		Snail Seed	
Moraceae	*Broussonetia*	*papyrifera*		Paper Mulberry	
Moraceae	*Ficus*	*carica*		Common Fig	Higuera
Moraceae	*Morus*	*alba*		White Mulberry	Mora Blanca
Moraceae	*Morus*	*nigra*		Black Mulberry	Mora Negra
Najadaceae	*Najas*	*guadalupensis*			
Nyctaginaceae	*Acleisanthes*	*longiflora*		Angel Trumpets	
Nyctaginaceae	*Acleisanthes*	*obtusa*			
Nyctaginaceae	*Allionia*	*incarnata*			
Nyctaginaceae	*Boerhavia*	*diffusa*			
Nyctaginaceae	*Boerhavia*	*erecta*			
Nyctaginaceae	*Commicarpus*	*scandens*			
Nyctaginaceae	*Mirabilis*	*jalapa*		Common Four-o'clock	
Nyctaginaceae	*Nyctaginia*	*capitata*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Nyctaginaceae	*Pisonia*	*aculeata*		Devil's Claw	Garabato Prieto
Nymphaeaceae	*Nymphaea*	*elegans*		Blue Water Lily	Lampazos
Nymphaeaceae	*Nymphaea*	*mexicana*		Yellow Water-Lily	
Oleaceae	*Forestiera*	*angustifolia*		Elbow Bush	Panalero
Oleaceae	*Fraxinus*	*berlandieriana*		Rio Grande Ash	Fresno
Oleaceae	*Menodora*	*heterophylla*			
Onagraceae	*Gaura*	*coccinea*			
Onagraceae	*Gaura*	*parviflora*		Small-Flowered Guara	
Onagraceae	*Gaura*	*sinuata*		Wavy-leaved Guara	
Onagraceae	*Gaura*	*suffulta*		Wild Honeysuckle, Kisses	
Onagraceae	*Ludwigia*	*octovalvis*			
Onagraceae	*Ludwigia*	*peploides*			
Onagraceae	*Oenothera*	*grandis*			
Onagraceae	*Oenothera*	*kunthiana*		Evening Primrose	
Onagraceae	*Oenothera*	*laciniata*			
Onagraceae	*Oenothera*	*rosea*			
Onagraceae	*Oenothera*	*speciosa*		Showy Evening Primrose	
Onagraceae	*Oenothera*	*triloba*			
Orobanchaceae	*Orobanche*	*ludoviciana*		Louisiana Broomrape	
Oxalidaceae	*Oxalis*	*dichondrifolia*			
Oxalidaceae	*Oxalis*	*dillenii*			
Oxalidaceae	*Oxalis*	*drummondii*			
Papaveraceae	*Argemone*	*aenea*		Yellow Prickly Poppy	
Papaveraceae	*Argemone*	*albiflora*	texana	White Prickly Poppy	Flor de San Juan
Papaveraceae	*Argemone*	*mexicana*			
Papaveraceae	*Argemone*	*sanguinea*		Red Poppy	
Passifloraceae	*Passiflora*	*filipes*			
Passifloraceae	*Passiflora*	*foetida*	gossypiifolia		Corona de Cristo
Passifloraceae	*Passiflora*	*suberosa*		Passion Flower	
Passifloraceae	*Passiflora*	*tenuiloba*			
Phytolaccaceae	*Petiveria*	*alliacea*		Garlic Weed	Hierba De Las Gallintas
Phytolaccaceae	*Phaulothamnus*	*spinescens*		Snake-eyes	Ojo de Víbora
Phytolaccaceae	*Rivina*	*humilis*		Pigeon Berry	
Plantaginaceae	*Plantago*	*hybrida*		Plantain	
Plantaginaceae	*Plantago*	*rhodosperma*		Red-Seeded Plantain	
Plumbaginaceae	*Limonium*	*nashii*			
Plumbaginaceae	*Plumbago*	*scandens*			Hierba del Alacran
Poaceae	*Andropogon*	*gerardii*	gerardii	Big Bluestem	
Poaceae	*Andropogon*	*glomeratus*		Bushy Beardgrass	
Poaceae	*Andropogon*	*ternarius*		Splitbeard Bluestem	
Poaceae	*Aristida*	*adscensionis*		Six-Weeks Three-Awn	
Poaceae	*Aristida*	*longespica*		Three-Awn	
Poaceae	*Aristida*	*purpurea*		Purple Three-Awn	
Poaceae	*Aristida*	*roemeriana*		Roemer Three-Awn	

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Poaceae	*Aristida*	*wrightii*		Wright Three-Awn	
Poaceae	*Arundo*	*donax*		Giant Cane	Carrizo
Poaceae	*Bothriochloa*	*ischaemum*	songarica	King Ranch Bluestem	
Poaceae	*Bothriochloa*	*saccharoides*	longipaniculata	Longspike Silver Bluestem	
Poaceae	*Bouteloua*	*aristidoides*		Needle Grama	
Poaceae	*Bouteloua*	*hirsuta*		Hairy Grama	
Poaceae	*Bouteloua*	*rigidiseta*		Texas Grama	
Poaceae	*Bouteloua*	*trifida*		Red Grama	
Poaceae	*Bromus*	*unioloides*		Rescuegrass	
Poaceae	*Buchloë*	*dactyloides*		Buffalograss	Zacate Chino
Poaceae	*Cenchrus*	*ciliaris*		Buffelgrass	
Poaceae	*Cenchrus*	*echinatus*		Southern Sandbur	
Poaceae	*Cenchrus*	*incertus*		Sandbur, Grassbur	
Poaceae	*Cenchrus*	*myosuroides*		Big Sandbur	
Poaceae	*Chloris*	*andropogonoides*		Slimspike Windmillgrass	
Poaceae	*Chloris*	*canterai*			
Poaceae	*Chloris*	*chloridea*		Buryseed Chloris	
Poaceae	*Chloris*	*ciliata*		Fringed Chloris	
Poaceae	*Chloris*	*crinita*		False Rhodesgrass	
Poaceae	*Chloris*	*cucullata*		Hooded Windmillgrass	
Poaceae	*Chloris*	*gayana*		Rhodesgrass	
Poaceae	*Chloris*	*pluriflora*		Multiflowered False Rhodesgrass	
Poaceae	*Chloris*	*subdolichostachya*		Shortspike Windmillgrass	
Poaceae	*Chloris*	*verticillata*		Windmillgrass	
Poaceae	*Chloris*	*virgata*		Showy Chloris	
Poaceae	*Cynodon*	*dactylon*		Bermudagrass	
Poaceae	*Dactyloctenium*	*aegyptium*		Crowfoot	
Poaceae	*Dichanthium*	*annulatum*		Kleberg Bluestem	
Poaceae	*Dichanthium*	*aristatum*		Angleton Bluestem	
Poaceae	*Dichanthium*	*sericeum*		Silky Bluestem	
Poaceae	*Digitaria*	*bicornis*			
Poaceae	*Digitaria*	*californica*		California Cottontop	
Poaceae	*Digitaria*	*cognata*	arenicola	Sand Witchgrass	
Poaceae	*Digitaria*	*insularis*		Sourgrass	
Poaceae	*Digitaria*	*patens*		Texas Cottontop	
Poaceae	*Distichlis*	*spicata*		Saltgrass	Zacate Salado
Poaceae	*Echinochloa*	*colona*		Junglerice	
Poaceae	*Echinochloa*	*crusgalli*		Barnyardgrass	
Poaceae	*Eleusine*	*indica*		Goosegrass	
Poaceae	*Eragrostis*	*barrelieri*		Mediterranean Lovegrass	
Poaceae	*Eragrostis*	*cilianensis*		Stinkgrass	
Poaceae	*Eragrostis*	*curtipedicillata*		Gummy Lovegrass	
Poaceae	*Eragrostis*	*lugens*		Mourning Lovegrass	
Poaceae	*Eragrostis*	*secundiflora*		Red Lovegrass	

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Poaceae	*Eragrostis*	*sessilispica*		Tumble Lovegrass	
Poaceae	*Eragrostis*	*spectabilis*		Purple Lovegrass	
Poaceae	*Eragrostis*	*spicata*		Spicate Lovegrass	
Poaceae	*Eriochloa*	*contracta*		Prairie Cupgrass	
Poaceae	*Eriochloa*	*punctata*		Louisianna Cupgrass	
Poaceae	*Eriochloa*	*sericea*		Texas Cupgrass	
Poaceae	*Erioneuron*	*pilosum*		Hairy Tridens	
Poaceae	*Hemarthria*	*altissima*		African Jointtail	
Poaceae	*Hilaria*	*belangeri*		Common Curlymesquite	
Poaceae	*Hordeum*	*pusillum*		Little Barley	
Poaceae	*Leersia*	*hexandra*		Clubhead Cutgrass	
Poaceae	*Leersia*	*monandra*		Bunch Cutgrass	
Poaceae	*Leptochloa*	*dubia*		Green Sprangletop	
Poaceae	*Leptochloa*	*fascicularis*		Sprangletop	
Poaceae	*Leptochloa*	*filiformis*		Red Sprangletop	
Poaceae	*Leptochloa*	*nealleyi*		Nealley Sprangletop	
Poaceae	*Leptochloa*	*uninervia*		Mexican Sprangletop	
Poaceae	*Leptochloa*	*virgata*		Tropic Sprangletop	
Poaceae	*Leptoloma*	*cognatum*	cognatum	Fall Witchgrass	
Poaceae	*Limnodea*	*arkansana*		Ozarkgrass	
Poaceae	*Monanthochloë*	*littoralis*		Shore Grass	
Poaceae	*Neeragrostis*	*reptans*		Creeping Lovegrass	
Poaceae	*Oplismenus*	*hirtellus*		Basketgrass	
Poaceae	*Panicum*	*antidotale*		Blue Panicum	
Poaceae	*Panicum*	*diffusum*		Spreading Panicum	
Poaceae	*Panicum*	*fasciculatum*		Browntop Panic Grass	
Poaceae	*Panicum*	*hallii*	filipes	Filly Panicum	
Poaceae	*Panicum*	*ghiesbreghtii*		Ghiesbreght Panicum	
Poaceae	*Panicum*	*hallii*	hallii	Halls Panicum	
Poaceae	*Panicum*	*hirsutum*		Hairy Panicum	
Poaceae	*Panicum*	*maximum*		Guineagrass	
Poaceae	*Panicum*	*obtusum*		Vine Mesquite	
Poaceae	*Panicum*	*purpurascens*		Paragrass	
Poaceae	*Panicum*	*texanum*		Texas Panicum, Millet	
Poaceae	*Pappophorum*	*bicolor*		Pink Pappusgrass	
Poaceae	*Pappophorum*	*vaginatum*		Whiplash Pappusgrass	
Poaceae	*Paspalidium*	*geminatum*			
Poaceae	*Paspalum*	*distichum*		Knotgrass	
Poaceae	*Paspalum*	*langei*		Rustyseed Paspalum	
Poaceae	*Paspalum*	*lividum*		Longtom	
Poaceae	*Paspalum*	*pubiflorum*			
Poaceae	*Phragmites*	*australis*		Common Reed	
Poaceae	*Saccharum*	*officinarum*		Sugar cane	Caña
Poaceae	*Setaria*	*adhaerans*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Poaceae	*Setaria*	*geniculata*		Knotroot Bristlegrass	
Poaceae	*Setaria*	*leucopila*		Plains Bristlegrass	
Poaceae	*Setaria*	*macrostachya*			
Poaceae	*Setaria*	*ramiseta*			
Poaceae	*Setaria*	*scheelei*			
Poaceae	*Setaria*	*texana*			
Poaceae	*Sorghum*	*halepense*		Johnsongrass	
Poaceae	*Spartina*	*alterniflora*		Smooth Cordgrass	Sacahuiste
Poaceae	*Spartina*	*cynosuroides*		Big Cordgrass	Sacahuiste
Poaceae	*Spartina*	*patens*		Marshhay Cordgrass	Sacahuiste
Poaceae	*Spartina*	*spartinae*		Gulf Cordgrass	Sacahuiste
Poaceae	*Sporobolus*	*buckleyi*		Buckley Dropseed	
Poaceae	*Sporobolus*	*contractus*		Spike Dropseed	
Poaceae	*Sporobolus*	*cryptandrus*		Sand Dropseed	
Poaceae	*Sporobolus*	*pyramidatus*		Whorled Dropseed	
Poaceae	*Sporobolus*	*tharpii*		Padre Island Dropsee0d	
Poaceae	*Sporobolus*	*vaginiflorus*			
Poaceae	*Sporobolus*	*virginicus*		Seashore Dropseed	
Poaceae	*Sporobolus*	*wrightii*		Big Alkali Sacaton	
Poaceae	*Stenotaphrum*	*secundatum*		St. Augustine Grass	
Poaceae	*Tragus*	*berteronianus*		Spike Burgrass	
Poaceae	*Tricholaena*	*rosea*		Natal Grass	
Poaceae	*Trichoneura*	*elegans*		Silveusgrass	
Poaceae	*Tridens*	*albescens*		White Tridens	
Poaceae	*Tridens*	*eragrostoides*			
Poaceae	*Tridens*	*muticus*			
Poaceae	*Tridens*	*texanus*		Texas Tridens	
Poaceae	*Urochloa*	*panicoides*		Liverseed Grass, Cowkiller	
Poaceae	*Vaseyochloa*	*multinervosa*		Texasgrass	
Polemoniaceae	*Gilia*	*incisa*			
Polemoniaceae	*Gilia*	*rigidula*			
Polygalaceae	*Polygala*	*glandulosa*			
Polygonaceae	*Antigonon*	*leptopus*		Queen's Wreath	Corona de la Reina
Polygonaceae	*Eriogonum*	*greggii*			
Polygonaceae	*Eriogonum*	*multiflorum*		Wild Buckwheat	
Polygonaceae	*Polygonum*	*densiflorum*		Stout Smartweed	
Polygonaceae	*Polygonum*	*pensylvanicum*			
Polygonaceae	*Polygonum*	*persicaria*		Lady's Thumb	Moco de Guajolote
Polygonaceae	*Polygonum*	*punctatum*		Water Smartweed	
Polygonaceae	*Rumex*	*chrysocarpus*			
Polygonaceae	*Rumex*	*pulcher*		Fiddle Dock	
Polypodiaceae	*Azolla*	*caroliniana*			
Polypodiaceae	*Cheilanthes*	*sinuata*			
Polypodiaceae	*Marsilea*	*macropoda*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Polypodiaceae	*Notholaena*	*sinuata*		Wavy Cloakfern	
Pontederiaceae	*Eichhornia*	*crassipes*		Water Hyacinth	
Pontederiaceae	*Heteranthera*	*liebmannii*			
Portulacaceae	*Portulaca*	*pilosa*		Chisme	
Portulacaceae	*Portulaca*	*umbraticola*			
Portulacaceae	*Talinum*	*aurantiacum*			
Portulacaceae	*Talinum*	*paniculatum*			
Potamogetonaceae	*Potamogeton*	*nodosus*			
Potamogetonaceae	*Potamogeton*	*pectinatus*			
Primulaceae	*Anagallis*	*arvensis*			
Primulaceae	*Samolus*	*ebracteatus*			
Primulaceae	*Samolus*	*parviflorus*			
Ranunculaceae	*Clematis*	*drummondii*		Texas Virgin's Bower	
Resedaceae	*Oligomeris*	*linifolia*			
Rhamnaceae	*Colubrina*	*texensis*		Texas Colubrina	
Rhamnaceae	*Condalia*	*hookeri*		Brasil	Capul Negro
Rhamnaceae	*Condalia*	*spathulata*		Knife-Leaf Condalia	
Rhamnaceae	*Karwinskia*	*humboldtiana*			Coyotillo
Rhamnaceae	*Ziziphus*	*obtusifolia*		Lotebush	Clepe
Rosaceae	*Prunus*	*persica*		Peach	Duranzo
Rosaceae	*Rubus*	*trivialis*		Southern Dewberry	Zarzamora
Rubiaceae	*Cephalanthus*	*occidentalis*		Buttonbush	
Rubiaceae	*Cephalanthus*	*salicifolius*		Mexican Buttonbush	
Rubiaceae	*Chiococca*	*alba*		David's Milkberry	
Rubiaceae	*Galium*	*aparine*			
Rubiaceae	*Randia*	*rhagocarpa*			Crucillo
Rubiaceae	*Spermacoce*	*glabra*			
Rutaceae	*Amyris*	*madrensis*		Sierra Madre Torchwood	
Rutaceae	*Amyris*	*texana*			Chapotillo
Rutaceae	*Esenbeckia*	*runyonii*			Limoncillo
Rutaceae	*Helietta*	*parvifolia*			Barreta
Rutaceae	*Thamnosma*	*texana*		Dutchman's Breeches	Ruda Del Monte
Rutaceae	*Zanthoxylum*	*fagara*		Lime Prickly-Ash	Colima
Salicaceae	*Salix*	*babylonica*			
Salicaceae	*Salix*	*exigua*		Sandbar Willow	
Salicaceae	*Salix*	*interior*			
Salicaceae	*Salix*	*nigra*		Black Willow	Sauz
Sapindaceae	*Cardiospermum*	*corindum*		Tropical Heartseed	
Sapindaceae	*Cardiospermum*	*dissectum*		Chihuahua Balloon-Vine	
Sapindaceae	*Cardiospermum*	*halicacabum*		Common Balloon-Vine	Farolitos
Sapindaceae	*Sapindus*	*drummondii*		Western Soapberry	Jaboncillo
Sapindaceae	*Sapindus*	*saponaria*	drummondii	Western Soapberry	Jaboncillo
Sapindaceae	*Serjania*	*brachycarpa*		Short-Fruited Serjania	
Sapindaceae	*Urvillea*	*ulmacea*			

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Sapotaceae	*Bumelia*	*celastrina*		Coma	Coma
Scrophulariaceae	*Agalinis*	*heterophylla*			
Scrophulariaceae	*Bacopa*	*monnieri*		Water Hyssop	
Scrophulariaceae	*Leucophyllum*	*frutescens*		Purple Sage	Cenizo
Scrophulariaceae	*Maurandya*	*antirrhiniflora*			
Scrophulariaceae	*Mecardonia*	*vandellioides*		Prostrate Mecardonia	
Scrophulariaceae	*Veronica*	*peregrina*			
Simaroubaceae	*Castela*	*texana*		Allthorn Goatbush	Chaparro Amargosa
Simaroubaceae	*Castela*	*erecta*	texana	Allthorn Goatbush	Chaparro Amargoso
Solanaceae	*Capsicum*	*annuum*		Bird Pepper	Chilipiquín
Solanaceae	*Chamaesaracha*	*coronopus*			
Solanaceae	*Lycium*	*berlandieri*		Berlandier Wolfberry	
Solanaceae	*Lycium*	*carolinianum*	quadrifidum	Carolina Wolfberry	
Solanaceae	*Lycopersicon*	*lycopersicum*		Cherry Tomato	
Solanaceae	*Margaranthus*	*solanaceus*		Netted Globe-berry	
Solanaceae	*Nicotiana*	*glauca*		Tree Tobacco	
Solanaceae	*Nicotiana*	*repanda*		Fiddle Leaf Tobacco	
Solanaceae	*Nicotiana*	*trigonophylla*			
Solanaceae	*Petunia*	*parviflora*			
Solanaceae	*Physalis*	*angulata*			
Solanaceae	*Physalis*	*cinerascens*		Ground Cherry	
Solanaceae	*Physalis*	*mollis*	variovestita		
Solanaceae	*Physalis*	*pubescens*		Downy Ground Cherry	
Solanaceae	*Physalis*	*viscosa*	cinarescens	Ground Cherry	
Solanaceae	*Quincula*	*lobata*			
Solanaceae	*Solanum*	*americanum*		Black Nightshade	
Solanaceae	*Solanum*	*campechiense*		Campeche Nightshade	
Solanaceae	*Solanum*	*carolinense*		Carolina Horse Nettle	
Solanaceae	*Solanum*	*elaeagnifolium*		Silver-Leaf Nightshade	Trompillo
Solanaceae	*Solanum*	*nodiflorum*			
Solanaceae	*Solanum*	*rostratum*		Buffalo Bur	
Solanaceae	*Solanum*	*triquetrum*		Texas Nightshade	
Sterculiaceae	*Ayenia*	*limitaris*			
Sterculiaceae	*Ayenia*	*pilosa*			
Sterculiaceae	*Melochia*	*pyramidata*		Pyramid-Bush	
Sterculiaceae	*Melochia*	*tomentosa*		Woolly Pyramid-Bush	
Sterculiaceae	*Waltheria*	*indica*			Hierba del Soldado
Tamaricaceae	*Tamarix*	*aphylla*			
Tamaricaceae	*Tamarix*	*gallica*			Tamarisco
Taxodiaceae	*Taxodium*	*mucronatum*		Montezuma Bald Cypress	Sabino
Turneraceae	*Turnera*	*diffusa*	aphrodisiaca		Damiana
Typhaceae	*Typha*	*angustifolia*		Narrow-Leaved Cat-Tail	Tule
Typhaceae	*Typha*	*domingensis*		Cat-Tail	Tule
Ulmaceae	*Celtis*	*laevigata*		Sugar Hackberry	Palo Blanco

FAMILY	GENUS	SPECIES	VARIETY	NAME	SPANISH NAME
Ulmaceae	*Celtis*	*pallida*		Spiny Hackberry	Granjeno
Ulmaceae	*Ulmus*	*crassifolia*		Cedar Elm	Olmo
Urticaceae	*Parietaria*	*floridana*		Pellitory	
Urticaceae	*Parietaria*	*pensylvanica*			
Urticaceae	*Urtica*	*chamaedryoides*	runyonii		
Verbenaceae	*Aloysia*	*gratissima*		Whitebrush	Jazminillo
Verbenaceae	*Aloysia*	*macrostachya*		Woolly Bee-Brush	Vara Dulce
Verbenaceae	*Avicennia*	*germinans*		Black Mangrove	Mangle Negro
Verbenaceae	*Citharexylum*	*berlandieri*		Berlandier's Fiddlewood	Orcajuela
Verbenaceae	*Citharexylum*	*brachyanthum*		Mexican Fiddlewood	
Verbenaceae	*Citharexylum*	*spathulatum*		Mission Fiddlewood	
Verbenaceae	*Lantana*	*camara*		West Indies Lantana	Alfombrilla Hediona
Verbenaceae	*Lantana*	*horrida*		Texas Lantana	
Verbenaceae	*Lantana*	*macropoda*		Desert Lantana	Mejorana
Verbenaceae	*Lantana*	*microcephala*		Hammock Lantanas	Oregano
Verbenaceae	*Lippia*	*alba*		Bushy Lippia	Hierba Negra
Verbenaceae	*Lippia*	*graveolens*		Redbrush Lippia	Oregano Cimarrón
Verbenaceae	*Phyla*	*nodiflora*		Common Frogfruit	
Verbenaceae	*Phyla*	*strigulosa*		Diamond-Leaf Frogfruit	
Verbenaceae	*Priva*	*lappulacea*			
Verbenaceae	*Tetraclea*	*coulteri*			
Verbenaceae	*Verbena*	*bipinnatifida*		Mexican Vervain	
Verbenaceae	*Verbena*	*canescens*			
Verbenaceae	*Verbena*	*delticola*			Alfombrilla
Verbenaceae	*Verbena*	*officinalis*		Texas Vervain	
Verbenaceae	*Verbena*	*officinalis*	halei	Texas Vervain	
Verbenaceae	*Verbena*	*quadrangulata*			
Verbenaceae	*Verbena*	*runyonii*			
Verbenaceae	*Verbena*	*xutha*		Gulf Vervain	
Violaceae	*Hybanthus*	*verticillatus*			
Viscaceae	*Phoradendron*	*tomentosum*		Mistletoe	Injerto
Vitaceae	*Ampelopsis*	*arborea*		Pepper-Vine	
Vitaceae	*Cissus*	*incisa*		Marine Ivy	Hierba Del Buey
Zannichelliaceae	*Zannichellia*	*palustris*			
Zygophyllaceae	*Guaiacum*	*angustifolium*		Soap-Bush	Guayacán
Zygophyllaceae	*Kallstroemia*	*hirsutissima*			
Zygophyllaceae	*Porliera*	*angustifolia*		Soap-Bush	Guayacán
Zygophyllaceae	*Tribulus*	*terrestris*		Caltrop	Abrojo De Flor Amarilla

APPENDIX H

FEDERAL LISTING BY COUNTY

08/16/95

COMMON NAME	SCIENTIFIC NAME	STATUS
Cameron County		
American peregrine falcon	*Falco peregrinus anatum*	E
brown pelican	*Pelecanus occidentalis*	E
hawksbill sea turtle	*Eretmochelys imbricata*	E
jaguarundi	*Felis yagouaroundi*	E
Kemp's ridley sea turtle	*Lepidochelys kempi*	E
leatherback sea turtle	*Dermochelys coriacea*	E
northern aplomado falcon	*Falco femoralis septentrionalis*	E
ocelot	*Felis pardalis*	E
South Texas ambrosia	*Ambrosia cheiranthifolia*	E
Texas ayenia	*Ayenia limitaris*	E
West Indian manatee	*Trichechus manatus*	E
Arctic peregrine falcon	*Falco peregrinus tundrius*	T
bald eagle	*Haliaeetus leucocephalus*	T
green sea turtle	*Chelonia mydas*	T
loggerhead sea turtle	*Caretta caretta*	T
piping plover	*Charadrius melodus*	T
Hidalgo County		
American peregrine falcon	*Falco peregrinus anatum*	E
jagurundi	*Felis yagouaroundi*	E
northern aplomado falcon	*Falco femoralis septentrionalis*	E
ocelot	*Felis pardalis*	E
Texas ayenia	*Ayenia limitaris*	E
Walker's manioc	*Manihot walkerae*	E
Arctic peregrine falcon	*Falco peregrinus tundrius*	T
Starr County		
ashy dogweed	*Thymophylla tephroleuca*	E
interior least tern	*Sterna antillarum athalossos*	E
jaguarundi	*Felis yagouaroundi*	E
Johnston's frankenia	*Frankenia johnstonii*	E
ocelot	*Felis pardalis*	E
star cactus	*Astrophytum asterias*	E
Walker's manioc	*Manihot walkerae*	E
Willacy County		
American peregrine falcon	*Falco peregrinus anatum*	E
brown pelican	*Pelecanus occidentalis*	E
hawksbill sea turtle	*Eretmochelys imbricata*	E
jaguarundi	*Felis yagouaroundi*	E
Kemp's ridley sea turtle	*Lepidochelys kempi*	E
leatherback sea turtle	*Dermochelys coriacea*	E
northern aplomado falcon	*Falco femoralis septentrionalis*	E
ocelot	*Felis pardalis*	E
Arctic peregrine falcon	*Falco peregrinus tundrius*	T
green sea turtle	*Chelonia mydas*	T
loggerhead sea turtle	*Caretta caretta*	T
piping plover	*Charadrius melodus*	T

APPENDIX I

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Environmental Assessment

EA 1.0 Background

In 1979, the U.S. Fish and Wildlife Service (Service) initiated a long term program of acquiring Lower Rio Grande Valley (LRGV) lands for inclusion into the National Wildlife Refuge System. This land protection plan was designed to protect the remnants of existing native habitat to form a riparian corridor for plants and wildlife. Additionally, the project called for the reclamation of acquired agricultural lands in order to reestablish native habitats for the benefit of the native plant and wildlife resources throughout the ecosystem. Land acquisition continues to be the emphasis for the LRGV land protection program. Of the 132,000 acres proposed for acquisition in 1979, approximately 66,000 acres are currently under management by the LRGV National Wildlife Refuge (NWR). However, the need for a longer term plan focused on resource management has become an essential and ever increasing requirement for the enhancement and continued protection of fish and wildlife resources. It is important that Service lands be managed for the benefit of the continuum of ecological processes and not just individual geographic entities.

For that reason, the Service issued a draft Interim Comprehensive Management Plan (CMP) for both the LRGV NWR and the Santa Ana NWR in April 1997. The Service also prepared a draft Environmental Assessment (EA) as a companion document. Both of these documents were submitted to the public for review and comment prior to the issuance of a final CMP. Based upon input from the public, the Service has made adjustments to its proposed alternative.

EA 2.0 Purpose and Need for the Proposed Action

The Service's Refuge Manual states that the purpose of comprehensive management planning is to "provide long range guidance for the management of national wildlife refuges." [4 RM 1.1, Planning] Because (1) the refuge consists of many separate tracts of land dispersed throughout a four county area, (2) other agencies and entities are involved in land and natural resource management in the same area, (3) the multitude of management needs arising as additional lands are acquired, and (4) the increasing urban, international, and economic development pressures, it has become necessary to coordinate major natural resource decisions. This results in an ecosystem management approach rather than decision-making that would benefit only one particular resource over another. Planning provides a road map to facilitate the kind of coordination that is necessary to enhance the efficiency of implementing management actions designed to benefit the LRGV NWR, Santa Ana NWR, and the ecosystem. The Service's approach will be to offer management goals, objectives, strategies/ management actions that are consistent with ecologically desirable outcomes for the entire ecosystem.

EA 3.0 Description of the Proposed Action & Alternatives

EA 3.1 Alternative A : (Proposed Action)

The proposed action is to adopt and implement the Lower Rio Grande Valley / Santa Ana NWR Interim Comprehensive Management Plan. In general, the proposed action would provide for interim (5 to 10 years) preservation and enhancement of refuge resources and values in the planning area, pending completion of the protection goal of 132,500 acres. The management actions within the proposed alternative reflect a need to continue the major strategies of acquiring lands, protecting and restoring wetland values, continuing to provide a quality wildlife observation and interpretive program at Santa Ana NWR, and reforesting acquired farm lands.

Significant changes in the program include:

- The opening of selected tracts within the LRGV NWR. (See Map 8) for wildlife dependent public uses to include wildlife observation, and deer and dove hunting on selected tracts.
- The proposed alternative calls for refuge professionals to investigate the feasibility of implementing an experimental grazing program to assist with the revegetation efforts.
- The development of cooperative agreements with the many drainage and irrigation districts concerning habitat protection/ conservation, and water rights and their uses for refuge purposes.
- The identification of historically known grasslands and the reintroduction of native grasses on identified tracts.
- Development of a monitoring program to determine the long term success of wetland conservation/restoration projects in terms of water quality, and animal use in coordination with tbe Division of Ecological Services and various universities.
- Development of a revegetation management plan for the riparian edges along the flood control system in cooperation with International Boundary and Water Commission (IBWC).
- Development of interpretive kiosks on selected tracts within LRGV.

These actions among others would assist in the achievement of the following larger goals:

A. Protect Biological Diversity, Land and Waters, and Wildlife

GOAL: To restore, enhance, and protect the natural diversity of the Lower Rio Grande Valley including threatened and endangered species on and off refuge lands, through (1) land acquisition when appropriate, (2) the management of habitat and wildlife resources on refuge lands; and, (3) by strengthening existing, and establishing new cooperative efforts with public and private conservation agencies, and other government jurisdictions including Mexico.

B. Protect Water Rights, Water Management and the Management of Wetlands

GOAL: (1) To protect existing water rights holdings in the Area of Ecological Concern and obtain additional water rights, to the extent needed. (2) To improve the efficiency of water delivery systems and more effectively gauge water use for the benefit of refuge revegetation purposes and wetland restoration and enhancement purposes. (3) To achieve wetlands protection, enhancement, and rehabilitation within the Area of Ecological Concern.

C. Protect and Improve Water Quality

GOAL: (1) To improve refuge water quality and ensure water management projects are monitored for contamination and, (2) to reduce contaminant related fish and wildlife resource losses on lands and waters and minimize any impacts that are unavoidable.

D. Protect Cultural Resources

GOAL: To protect, maintain, and plan for Service managed cultural resources on the Lower Rio Grande Valley / Santa Ana NWR for the benefit of present and future generations.

E. Provide compatible wildlife dependent public uses, recreational opportunities, interpretation and education

GOALS: (1) To continue to offer a quality wildlife observational trail system on Santa Ana NWR.. (2) To offer compatible wildlife-dependent public access and recreational opportunities on tracts of the Lower Rio Grande Valley NWR that result in furthering the public's appreciation of Lower Rio Grande Valley Area of Ecological Concern and the National Wildlife Refuge System. This will be done by the provision of wildlife observation, photography, fishing, and hunting recreational opportunities in accordance with Executive Order 12996.[1] (3) To continue wildlife interpretation and educational efforts at Santa Ana NWR and initiate interpretive efforts for Lower Rio Grande Valley NWR in coordination with private groups and other jurisdictions.

EA 3.2 Alternative B: (No Action Alternative)

This alternative would focus on the continuation of land acquisition efforts, revegetation and wetland restoration efforts, but would not contain proposals to allow public access to LRGV tracts for wildlife dependent public uses. Unlike the proposed alternative, the refuge would not investigate the feasibility of experimental grazing on the refuge, or investigate the reestablishment of native grasses on selected tracts. Compatible public uses would be continued on Santa Ana NWR, but the Service would continue to disallow public uses and access to LRGV tracts.

EA 3.3 Alternative C

This alternative would call for the discontinuation of land acquisition efforts while focusing on revegetation and restoration of wetlands on existing tracts. Public uses would be restricted only to Santa Ana NWR. As in the proposed alternative, there would be efforts initiated to identify historical grasslands and revegetate selected tracts with native grasses, and to experiment with the use of grazing for revegetation purposes. Like the proposed alternative, the Service would develop agreements with the IBWC, the Texas Natural Resource Conservation Commission, and various irrigation districts to more efficiently make use of water resources.

[1] Recreational uses are considered Compatible when they do not "materially detract from or interfere with the purposes for which a refuge is established."

EA 3.4 Alternative D

This alternative would call for the continuation of land acquisition efforts only. Tracts, including many existing tracts, would no longer be actively revegetated nor would wetlands continue to be restored. The overall strategy would be to protect tracts by fencing and law enforcement efforts. The major management thrust would be primarily custodial. Public access and recreational uses would be continued at Santa Ana NWR. No tracts on theLRGV would be opened to public use or access. Fire management would consist solely of suppression strategies.

EA 4.0 Affected Environment

A description of the affected environment can be found in *Section 3.0* of the Draft Interim Comprehensive Management Plan for Lower Rio Grande Valley and Santa Ana NWR.

EA 5.0 Environmental Consequences

The following brief discussions and informal analyses pertain to key environmental issues and their relationship with each of the Alternatives considered in this document.

EA 5.1 Alternative A (Proposed Action)

As noted earlier, the proposed action would provide for interim (5 to 10 years) preservation and enhancement of refuge resources and values in the planning area, pending completion of the acquisition goal of 132,000 acres. The following sections briefly discuss the environmental consequences of adoption and implementation of Alternative A's proposed management strategies.

EA 5.1.1 Biological Resources

Land Acquisition and Management. A continuation of the overall land acquisition program and management of tracts will add lands to the LRGV corridor that can be reforested to improve the overall diversity of habitat and wildlife. Continuation of wetland management, revegetation, and protection will positively affect wildlife and habitat as was intended from the inception of the LRGV refuge acquisition program.

Public Use Proposals. The proposed opening of selected tracts within the LRGV for wildlife dependent public uses would have some effect upon both habitat and wildlife resources. Any activity proposed would have to undergo site-specific compatibility analysis. The types of wildlife-dependent activities contemplated include some fishing access in the Playa del Rio area, and the Rio Grande, hunting in the Upper Hidalgo-Willacy Management District, and wildlife observation on selected tracts as noted on Map 8. Some of the effects could include a flushing of birds, trampling of ground cover, and displacement of animals during human use periods. Other effects could be more indirect such as trash dispersal and potential for fire, both which could effect habitat and wildlife.

Experimental Grazing. Alternative A (Proposed) calls for the refuge professionals to consider the establishment of experimental grazing areas and protocols in efforts to benefit the refuge's revegetation efforts. These kinds of proposals would necessitate strict scientific protocols, and be regulated so that a permit to graze is never perceived as a "right" to graze into perpetuity. The effects would need to be studied in terms of desired brush densities and the presence of desired plant components resulting from grazing over time.

Cooperative Agreements. The development of new and strengthening of existing cooperative agreements with the many drainage and irrigation districts would benefit the refuge's ability to maintain the wetland components of its overall landscape. The stronger the refuge's ability to manage water, the stronger the benefit to habitat and wildlife components of the ecosystem.

Reintroduction of Native Grasses. The identification of historically known grasslands and the reintroduction of native grasses on selected tracts will improve the natural diversity of the landscape, positively effecting wildlife components.

Monitoring Program. Development of a strong monitoring program for wetland conservation/ restoration projects will benefit all habitat and wildlife components of the LRGV.

Revegetate Riparian Edges. Development of a revegetation management plan for the riparian edges along the flood control system in cooperation with IBWC will improve natural diversity in areas where mowing has reduced wildlife use and diversity.

EA 5.1.2 Air Quality

The refuge anticipates no negative impacts to the overall air quality of the ecosystem if Alternative A is adopted.

EA 5.1.3 Water Quality

Alternative A provides for the general improvement of the refuge's wetland areas to include better monitoring of water quality standards. Nothing in the alternative is anticipated to negatively impact water quality on Service lands.

EA 5.1.4 Wetland Preservation and Enhancement

Alternative A provides for the continuation of activities that improve the Service's wetland resources. Nothing in the alternative is anticipated to negatively impact wetland resources.

EA 5.1.5 Compatibility and Service Policy on Recreational Uses

Each of the proposals regarding the allowance of public uses on refuge lands will have to undergo compatibility analysis and an appropriate level of NEPA compliance prior to implementation. Depending on a specific proposal, alternatives may have to be developed and effects anticipated. Levels of use will have to be defined and the use will have to be appropriately regulated and monitored to lessen any anticipated impacts.

EA 5.1.6 Cultural Resources

The cultural resource component of the LRGV refuge lands is significant and any site specific proposals that might alter or effect the landscape will have to be considered in the context of potential effects to cultural and archeological resources. However, nothing in the proposed alternative is anticipated to negatively effect the refuge's cultural, historical, and archeological resources. Goal 4 of the proposed action calls for the specific protection of all LRGV refuge cultural resource.

EA 5.1.7 Socioeconomics

Nothing in the proposed alternative is anticipated to have negative effects to the economic or social context of the refuge lands. It is expected that the alternative's proposal for opening selected tracts for wildlife-dependent public recreation and access will provide an economic benefit to the overall economic region. For ecotourism alone, visitors can spend between $21 and$145 dollars during a visit to the local community. All refuges, like other federal lands, are important economic assets to both the national economy and the economies of the communities in which they are located.[2] A combination of local visitors and those from farther away provide a major source of revenue, enhancing the multiplier effect created by the constant flow of money.

EA 5.2 Alternative B (No Action)

EA 5.2.1 Biological Resources

Alternative B offers a strong level of protection for the biological resources on the refuge although without a set of updated goals and strategies. By adopting the "no action" alternative, the Refuge would anticipate no negative impacts to the overall landscape. Continued efforts to revegetate acquired lands and rehabilitate wetlands will benefit wildlife and habitat diversity in the LRGV area. Continued prohibitions on public access to the LRGV would eliminate potentials for even minor harm to ground cover and other habitat components. However, a lack of a strategic context of publicly accepted goals and strategies makes it more difficult for land managers to implement priorities. Indirectly, this could slow progress towards improving habitat and wildlife conditions refuge wide.

EA 5.2.2 Air Quality

There are no negative impacts anticipated to air quality by adoption of Alternative B.

[2] Kerlinger, Paul Phd, Ted Eubanks, R.H. Payne, 1994, The Economic Impact of Birding Ecotourism on communities Surrounding Eight National Wildlife Refuges, New Jersey Audubon Society.

EA 5.2.3 Water Quality

No negative effects are anticipated should Alternative B be adopted. The refuge would continue to monitor, to the degree possible, water quality in cooperation with the IBWC. Without a strategic context, it is difficult to determine the priority of this issue.

EA 5.2.4 Wetland Preservation and Enhancement

Under Alternative B the refuge would continue efforts to rehabilitate existing wetlands. Nothing proposed in this alternative is anticipated to have negative effects on the human environment.

EA 5.2.5 Compatibility and Service Policy on Recreational Uses

Under this alternative, the Service would not establish new access and recreational uses for LRGV lands other than those currently in place at Santa Ana NWR. The Service would be responsible to determine compatibility of wildlife dependent recreational uses on Santa Ana NWR. As no recreational uses would be established on LRGV, compatibility would not be an issue.

EA 5.2.6 Cultural Resources

The refuge's cultural resource component is significant any management activities on newly acquired tracts that have not been assessed for archeological and historical resources would have to under go such an assessment. As no cultural resource goals would be adopted per se, it would be difficult to list the priority of these kinds of activities. The lack of a strategic context could slow the Service's ability to employ strategies to foster better protection of cultural resources.

EA 5.2.7 Socioeconomics

The adoption of Alternative B would not result in the employment of strategies that would negatively affect the human environment including the economy of the LRGV region. The continued prohibitions on access and recreational use of LRGV NWR tracts would not be harmful to the economy; however, it could be argued that an important opportunity for growth in ecotourism in the area would be forgone. Nevertheless, under this Alternative, even though the LRGV NWR would not be open to public access, ecotourism visitors would still have a variety of opportunities for wildlife observation at Santa Ana NWR, Laguna Atascosa NWR, Sabal Palm Grove Sanctuary and other State and privately owned area along the Rio Grande Valley corridor.

EA 5.3 Alternative C

EA 5.3.1 Biological Resources

Under Alternative C, land acquisition efforts would stop and the refuge size would remain at 66,000 acres, allowing the LRGV staff to concentrate on revegetation efforts on existing tracts. Overall, discontinuing land acquisition efforts would lead to the availability of more land to be absorbed by land developers for industrial and housing purposes. This would have a negative effect on the long term prospects for improving habitat diversity and filling ecological gaps where habitat fragmentation currently exists. If the Service stopped at the current 66,000 acres of lands, eventually revegetation and wetland restoration efforts will have improved the situation in very localized areas where Service tracts are large enough to have a diversity of habitat. Even efforts to reestablish native grasses and the use of experimental grazing would have positive effects in very localized areas of the region. Gaps and habitat fragmentation would continue in many areas where ecosystem processes would not be interconnected. This would lessen any positive results from reforested and restored wetland units. If the refuge cannot create the necessary linkages through land acquisition, wildlife would continue to struggle on island habitats making it more difficult to foster the genetic diversity needed for the maintenance of diverse and sustainable wildlife populations.

EA 5.3.2 Air Quality

There would be no effect to air quality as a result of the adoption of Alternative C.

EA 5.3.3 Water Quality

There would be no effect to water quality as a result of the adoption of Alternative C. LRGV staff might be able to focus efforts toward improving water quality monitoring to some extent since they would not have to be concerned about new units coming on line.

EA 5.3.4 Wetland Preservation and Enhancement

The LRGV staff would be able to focus on existing tracts with wetland units without having to worry about new units coming on line. This could have a positive, albeit localized, effect.

EA 5.3.5 Compatibility and Service Policy on Recreational Uses

Compatible public use and recreation would continue to be restricted to the Santa Ana NWR.

EA 5.3.6 Cultural Resources

As the land acquisition process would cease under this alternative, the Refuge would only need to contend with cultural resources on those tracts currently under jurisdiction of the Service. As agricultural land is absorbed by an expanding urban population, undoubtedly historic and other cultural resources could be lost and would not have the protection afforded under Service ownership.

EA 5.3.7 Socioeconomics

Adoption of this alternative would have no negative impacts on the local economies. Ecotourism would continue to be a strong component even without the opening of access to LRGV tracts for wildlife-dependent recreation. Ecotourism visitors would still have a variety of opportunities for wildlife observation at Santa Ana NWR, Laguna Atascosa NWR, Sabal Palm Grove Sanctuary and other State and privately owned area along the Rio Grande Valley corridor.

EA 5.4 Alternative D

EA 5.4.1 Biological Resources

Under this alternative the Service would continue efforts to buy available lands on a willing seller basis, but efforts to revegetate lands and restore wetlands would be curtailed if not eliminated until the entire 132,500 acre goal is achieved and acquired lands can be assessed of their habitat and wildlife capabilities in a larger ecosystem context. This alternative could produce some negative impacts that would have to be more fully studied. Without an aggressive revegetation program, fallow farm lands that are purchased would end up as monotypical fields of exotic grasses and noxious weeds which have little or no wildlife value and become more of a fire hazard. Unplanned fires could do much to displace current wildlife populations by destroying the relatively few tracts with diverse habitats. Likewise, if wetlands are not restored and protected, the full wildlife capabilities of a particular unit may not be realized until wildlife populations and their natural habitats are so heavily depleted that any management becomes moot.

EA 5.4.2 Air Quality

Under Alternative D, should acquired fields become dense with noxious weeds and exotic grasses, the number of unplanned fires might increase, and thus increase carbon particulates due to smoke.

EA 5.4.3 Water Quality

There would possibly be impacts on water quality as a result of the adoption of Alternative D. Left unattended, resacas and other wetland resources would dry up, or the water quality might become a threat to wildlife and humans alike.

EA 5.4.4 Wetland Preservation and Enhancement

These activities would not take place until all of the 132,500 have been acquired. As noted earlier, if wetlands are not restored and protected soon after acquisition, the full wildlife capabilities of the unit would not be realized until wildlife populations and habitats are so depleted that any management efforts might be considered not cost effective. Custodial efforts do not do much to restore, enhance and protect vital and dynamic wetland processes that contribute significantly to overall wildlife diversity. Left unattended, resacas and other wetland resources would dry up, or the water quality might become a threat to wildlife and humans alike.

EA 5.4.5 Compatibility and Service Policy on Recreational Uses

Compatible public use and recreation would continue to be restricted to the Santa Ana NWR.

EA 5.4.6 Cultural Resources

As land is acquired, cultural resource assessments would be performed, but there would be no active excavation. Lands would be fenced and monitored by law enforcement.

EA 5.4.7 Socioeconomics

Adoption of this alternative would have no negative impacts on the local economies. Ecotourism visitors would continue to have a variety of opportunities for wildlife observation at Santa Ana NWR, Laguna Atascosa NWR, Sabal Palm Grove Sanctuary and other State and privately owned areas along the Rio Grande Valley corridor.

EA 6.0 Cumulative Impacts, Mitigation and Consultation and Coordination

EA 6.1 Cumulative Impacts

Cumulative impacts include impacts on the environment which result from incremental effects of the proposed action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

Implementing Alternative A would reduce any potential for cumulative impacts because of the strategic approach to managing refuge programs including wildlife-dependent public uses, and the consideration of resource conflicts and opportunities within a broad management framework. This would be a change from the issue-by-issue, problem-by-problem fragmented approach inherent in the No Action alternative.

Where site development activities are to be proposed during the next 5 to 10 years, each activity would be given the appropriate NEPA consideration. At that time, any required mitigation activities if any are necessary, would be designed into the specific project to reduce the level of impacts to the human environment and to protect fish and wildlife and their habitats.

EA 6.2 Mitigation Measures

Mitigation measures are necessary when effects are anticipated to be at the threshold of significance. Nothing proposed in Alternative A would produce environmental impacts that are near any level of significance so as to warrant mitigation measures. However, the activities listed below help reduce the risks that any negative effect will occur. Long-term monitoring will help in determining actual effects and how the Service should respond.

- The refuge would closely regulate any proposed activities to lessen any potential impacts such as restricting use to seasons and locations when known breeding and nesting activities are at a minimum.
- The refuge would prohibit any activities in areas where endangered species would be negatively affected.
- The refuge would establish a use-threshold to lessen potentials for ground compaction, trash, fire, and other damage to the natural landscape.
- The refuge would monitor uses and establish a system to keep track of numbers of users and adjust activity levels accordingly.
- Refuge grazing proposals would necessitate strict scientific protocols, and would be regulated so that a permit to graze is never perceived as a "right" to graze into perpetuity.
- The effects of grazing or grassland restoration efforts would need to be studied in terms of desired brush densities and the presence of desired plant components resulting from grazing over time.

EA 6.3 Consultation and Coordination

Public meetings were held in Brownsville, McAllen, and Rio Grande City in June 1995 and again in the month of February 1996. Copies of the Draft Interim

Comprehensive Management Plan and Draft EA were made available to the public, other governmental agencies, and interested organizations from March 28, 1997, through June 5, 1997. The Service received a number of comments and advice from the public and proceeded to consider them for incorporation. Copies of the record of correspondence are available upon request.

EA 7.0 Document Preparation

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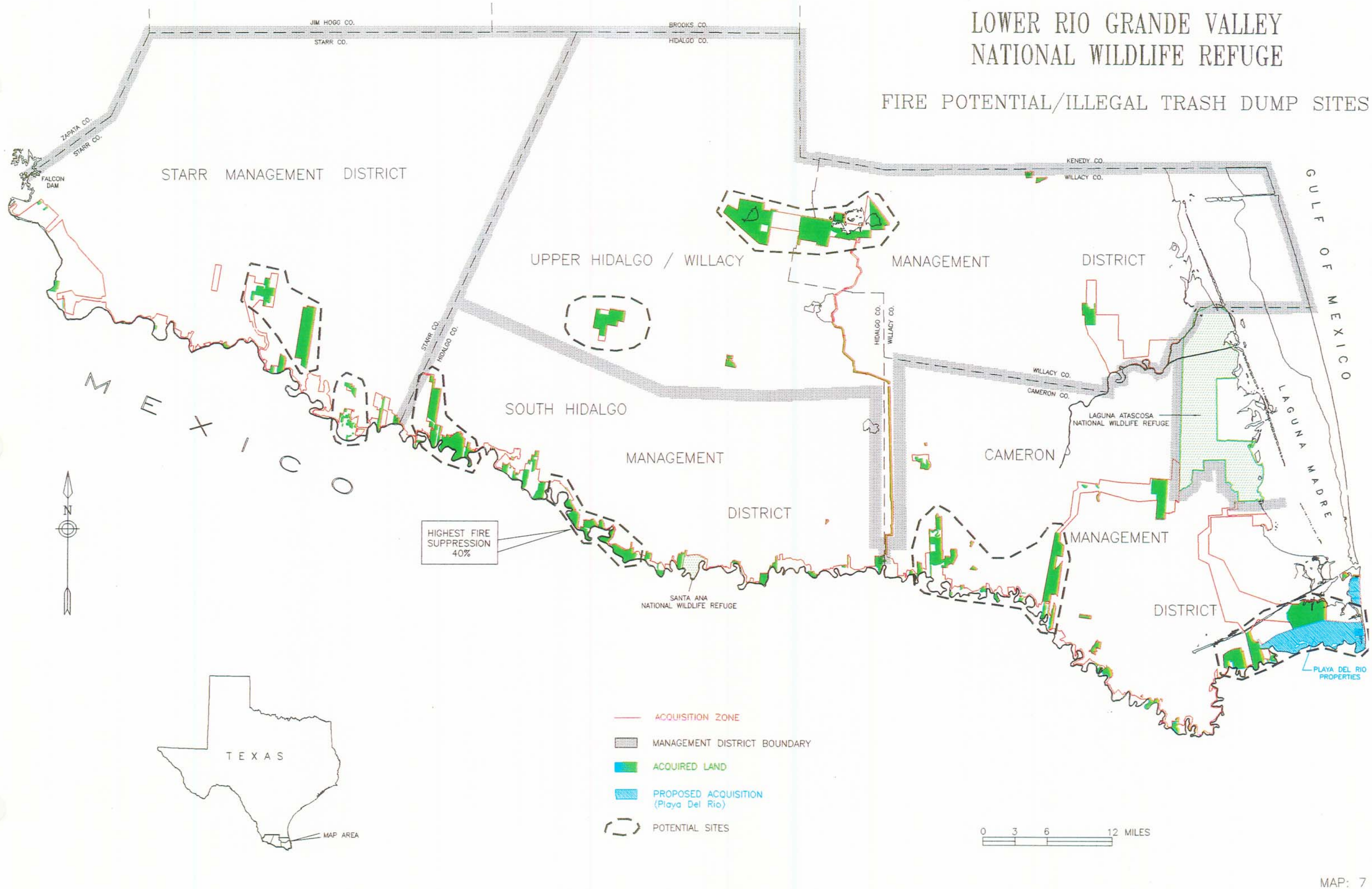
REGION 2 ECOSYSTEMS

LOWER RIO GRANDE VALLEY AREA OF ECOLOGICAL CONCERN

ECOSYTEMS UNIT NAMES

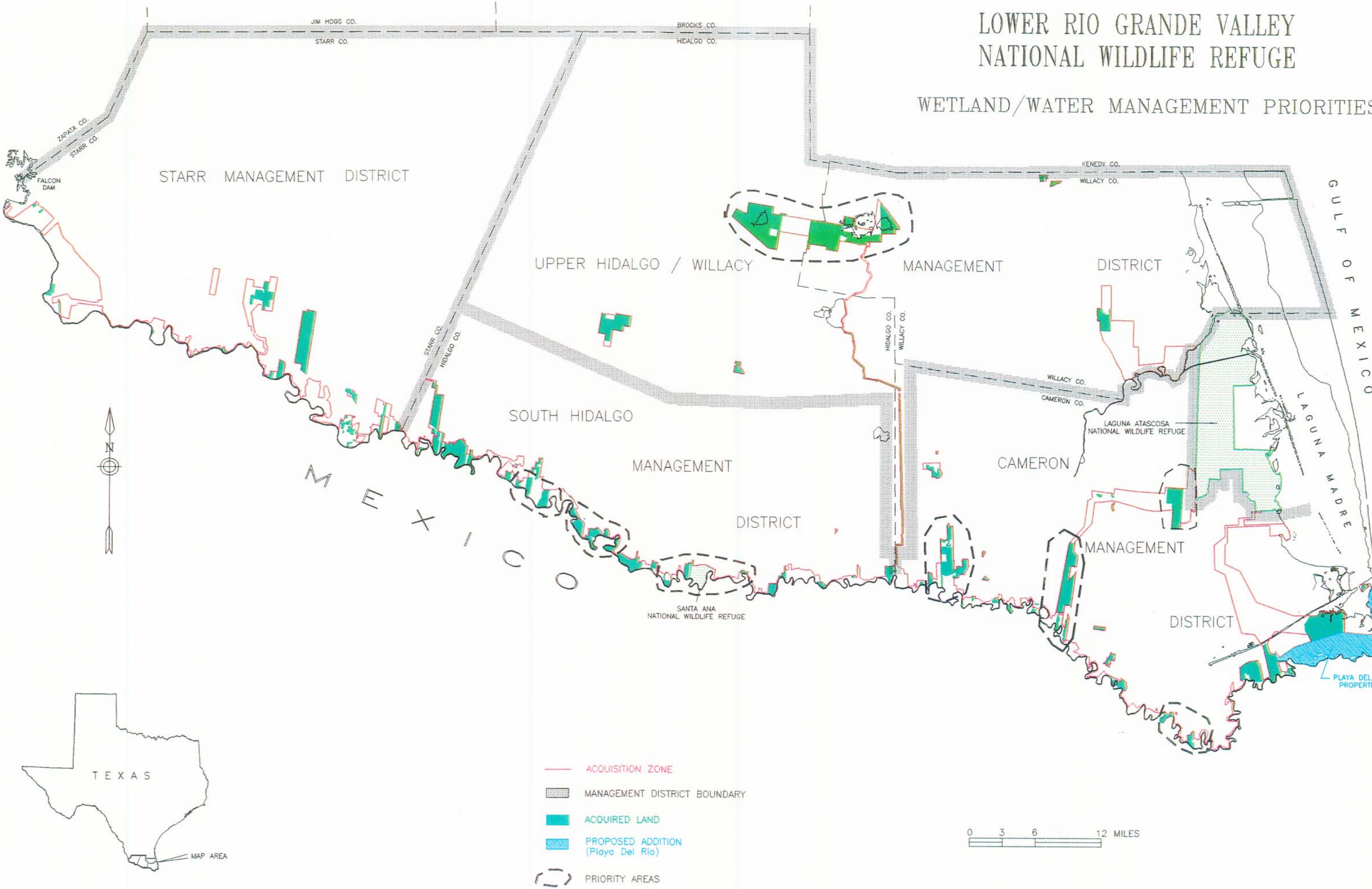
7. LOWER COLORADO RIVER
8. GILA/SALT/VERDE RIVER
9. MIDDLE AND UPPER RIO GRANDE
10. LOWER RIO GRANDE
11. PECOS RIVER
12. EDWARDS PLATEAU
13. EAST TEXAS
14. TEXAS GULF COAST
15. ARKANSAS/RED RIVERS
16. UPPER COLORADO RIVER (Region 6 responsibility)

MAP: 1


LOWER RIO GRANDE VALLEY
NATIONAL WILDLIFE REFUGE
FIRE POTENTIAL/ILLEGAL TRASH DUMP SITES
JIM HOGG CO.
STARR CO.
BROOKS CO.
HIDALGO CO.
ZAPATA CO.
STARR CO.
FALCON DAM
STARR MANAGEMENT DISTRICT
UPPER HIDALGO / WILLACY MANAGEMENT DISTRICT
KENEDY CO.
WILLACY CO.
GULF OF MEXICO
STARR CO.
HIDALGO CO.
HIDALGO CO.
WILLACY CO.
WILLACY CO.
CAMERON CO.
SOUTH HIDALGO MANAGEMENT DISTRICT
LAGUNA ATASCOSA NATIONAL WILDLIFE REFUGE
LAGUNA MADRE
CAMERON MANAGEMENT DISTRICT
MEXICO
HIGHEST FIRE SUPPRESSION 40%
SANTA ANA NATIONAL WILDLIFE REFUGE
PLAYA DEL RIO PROPERTIES
TEXAS
MAP AREA
ACQUISITION ZONE
MANAGEMENT DISTRICT BOUNDARY
ACQUIRED LAND
PROPOSED ACQUISITION (Playa Del Rio)
POTENTIAL SITES
0 3 6 12 MILES
MAP: 7

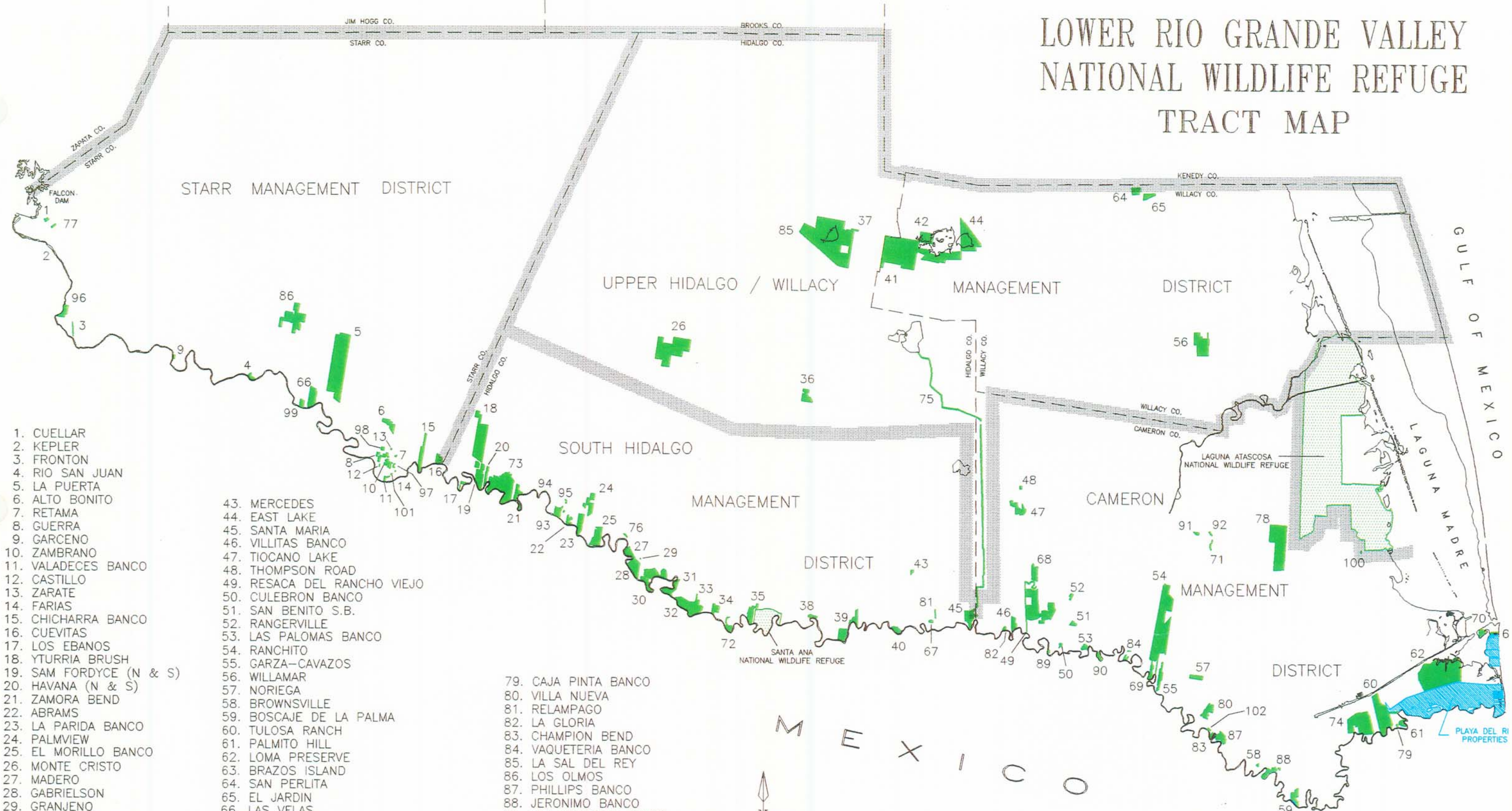
LOWER RIO GRANDE VALLEY NATIONAL WILDLIFE REFUGE

WETLAND/WATER MANAGEMENT PRIORITIES

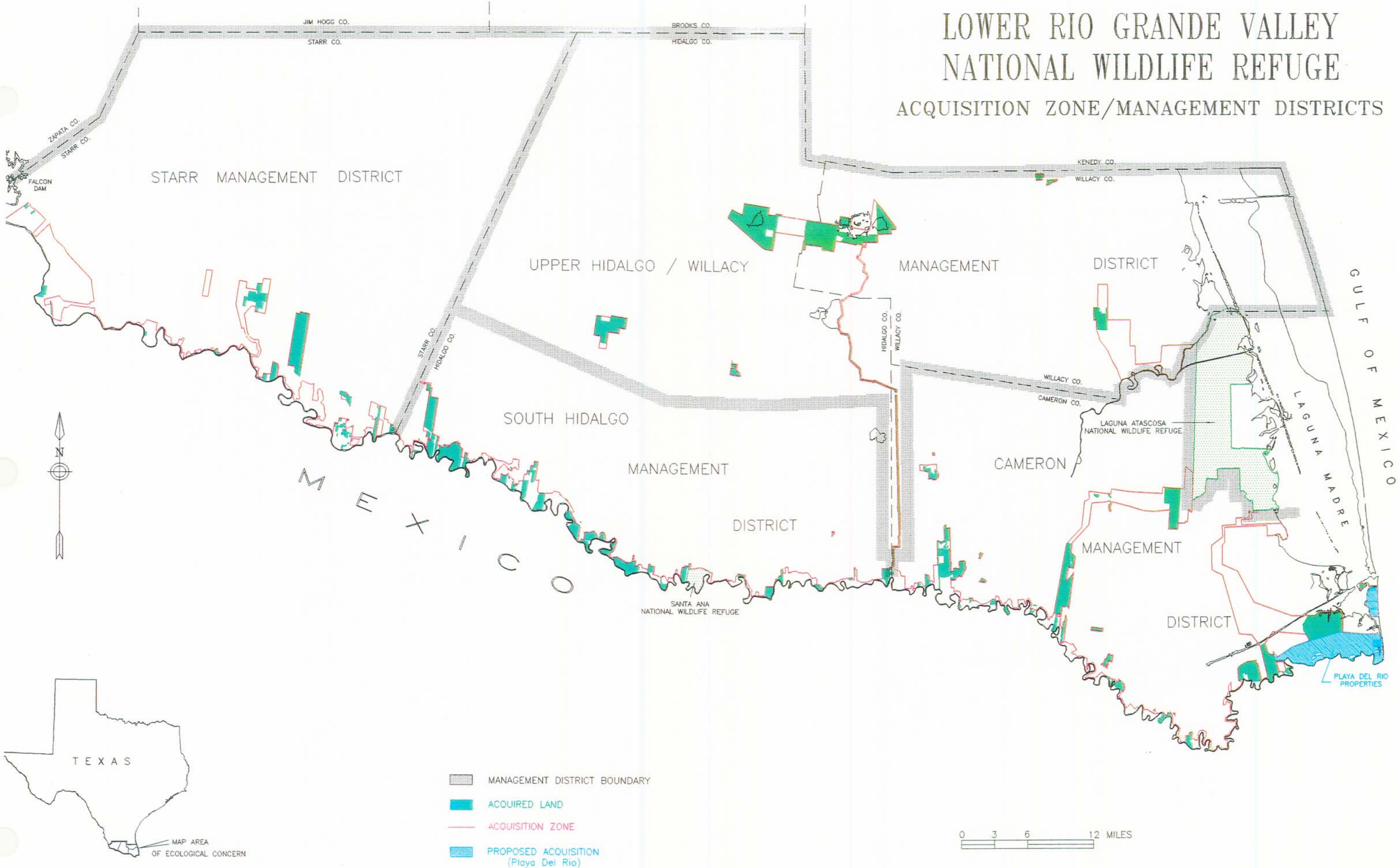


MAP: 6

LOWER RIO GRANDE VALLEY NATIONAL WILDLIFE REFUGE TRACT MAP

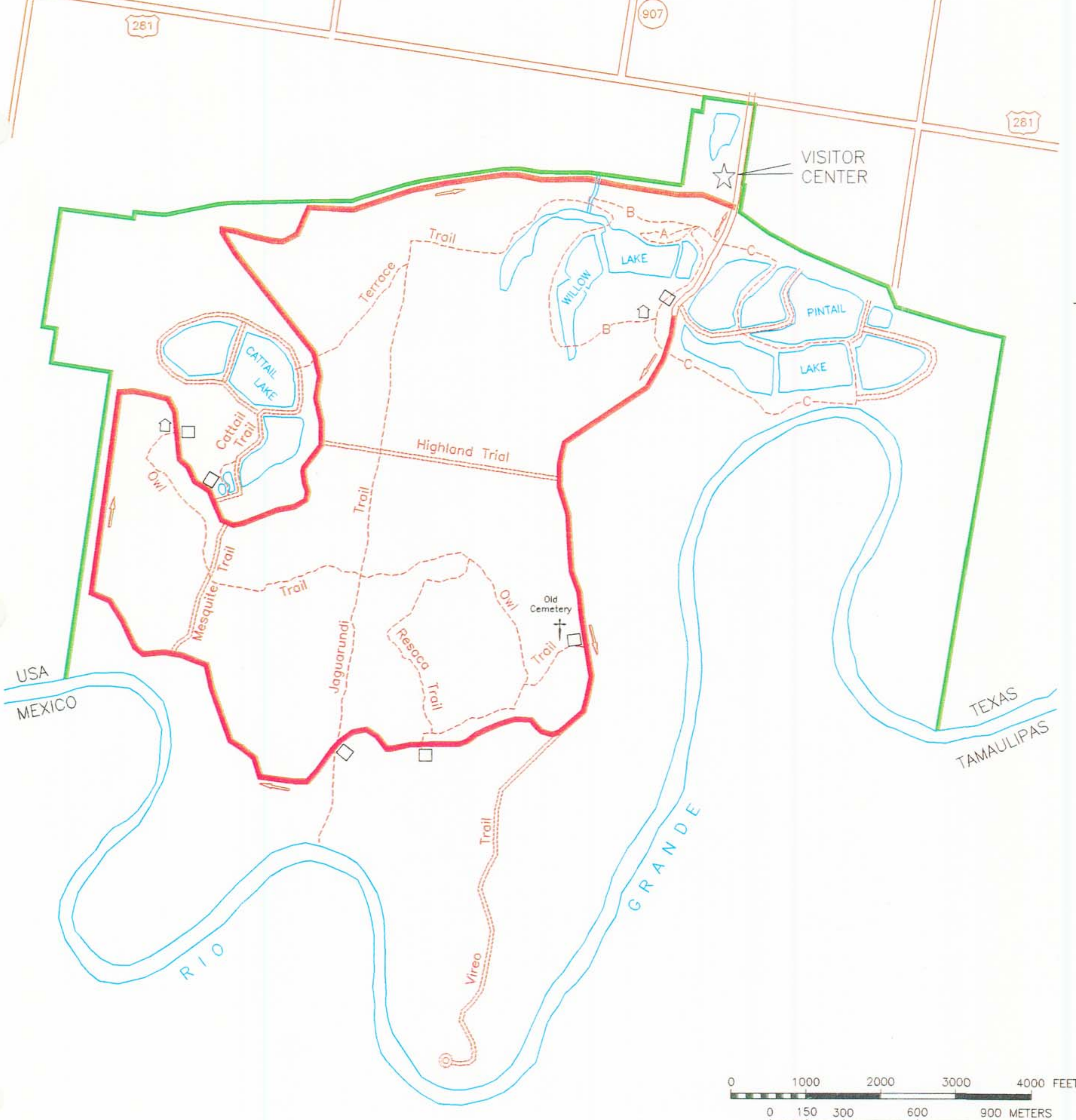


1. CUELLAR
2. KEPLER
3. FRONTON
4. RIO SAN JUAN
5. LA PUERTA
6. ALTO BONITO
7. RETAMA
8. GUERRA
9. GARCENO
10. ZAMBRANO
11. VALADECES BANCO
12. CASTILLO
13. ZARATE
14. FARIAS
15. CHICHARRA BANCO
16. CUEVITAS
17. LOS EBANOS
18. YTURRIA BRUSH
19. SAM FORDYCE (N & S)
20. HAVANA (N & S)
21. ZAMORA BEND
22. ABRAMS
23. LA PARIDA BANCO
24. PALMVIEW
25. EL MORILLO BANCO
26. MONTE CRISTO
27. MADERO
28. GABRIELSON
29. GRANJENO
30. COTTAM
31. PATE BEND
32. HIDALGO BEND
33. PHARR S. B.
34. VELA WOODS
35. MARINOFF
36. GOODFIELDS
37. SCHALEBEN
38. MONTERREY BANCO
39. LA COMA
40. LLANO GRANDE BANCO
41. TENIENTE
42. PAYNE
43. MERCEDES
44. EAST LAKE
45. SANTA MARIA
46. VILLITAS BANCO
47. TIOCANO LAKE
48. THOMPSON ROAD
49. RESACA DEL RANCHO VIEJO
50. CULEBRON BANCO
51. SAN BENITO S.B.
52. RANGERVILLE
53. LAS PALOMAS BANCO
54. RANCHITO
55. GARZA–CAVAZOS
56. WILLAMAR
57. NORIEGA
58. BROWNSVILLE
59. BOSCAJE DE LA PALMA
60. TULOSA RANCH
61. PALMITO HILL
62. LOMA PRESERVE
63. BRAZOS ISLAND
64. SAN PERLITA
65. EL JARDIN
66. LAS VELAS
67. ROSARIO BANCO
68. RESACA DE LOS FRESNOS
69. TAHUACHAL BANCO
70. CLARK ISLAND
71. LANTANA
72. MILAGRO
73. LA JOYA
74. VISTA DEL MAR
75. OTHA HOLLAND WILDLIFE CORRIDOR
76. TORTUGA BANCO
77. CHAPENO
78. LA SELVA VERDE
79. CAJA PINTA BANCO
80. VILLA NUEVA
81. RELAMPAGO
82. LA GLORIA
83. CHAMPION BEND
84. VAQUETERIA BANCO
85. LA SAL DEL REY
86. LOS OLMOS
87. PHILLIPS BANCO
88. JERONIMO BANCO
89. LAS SIERRITAS BANCO
90. CAPOTE BANCO
91. LOZANO
92. LAS YESCAS
93. ABRAMS–WEST
94. LA PESQUERA
95. LOMA VERDE
96. LAS RUINAS
97. VILLARREALES BANCO
98. GUERRA–NORTH
100. RESACA DE LA GRINGA
101. LOS ARBOLITOS
102. PALO BLANCO


LOWER RIO GRANDE VALLEY
NATIONAL WILDLIFE REFUGE
ACQUISITION ZONE/MANAGEMENT DISTRICTS
JIM HOGG CO.
STARR CO.
BROOKS CO.
HIDALGO CO.
ZAPATA CO.
STARR CO.
FALCON DAM
STARR MANAGEMENT DISTRICT
UPPER HIDALGO / WILLACY
MANAGEMENT
DISTRICT
KENEDY CO.
WILLACY CO.
STARR CO.
HIDALGO CO.
HIDALGO CO.
WILLACY CO.
WILLACY CO.
CAMERON CO.
SOUTH HIDALGO
MANAGEMENT
DISTRICT
CAMERON
MANAGEMENT
DISTRICT
LAGUNA ATASCOSA NATIONAL WILDLIFE REFUGE
LAGUNA MADRE
GULF OF MEXICO
MEXICO
SANTA ANA NATIONAL WILDLIFE REFUGE
PLAYA DEL RIO PROPERTIES
N
TEXAS
MAP AREA OF ECOLOGICAL CONCERN
MANAGEMENT DISTRICT BOUNDARY
ACQUIRED LAND
ACQUISITION ZONE
PROPOSED ACQUISITION (Playa Del Rio)
0 3 6 12 MILES

MAP: 4

SANTA ANA
NATIONAL WILDLIFE REFUGE
HIDALGO COUNTY, TEXAS

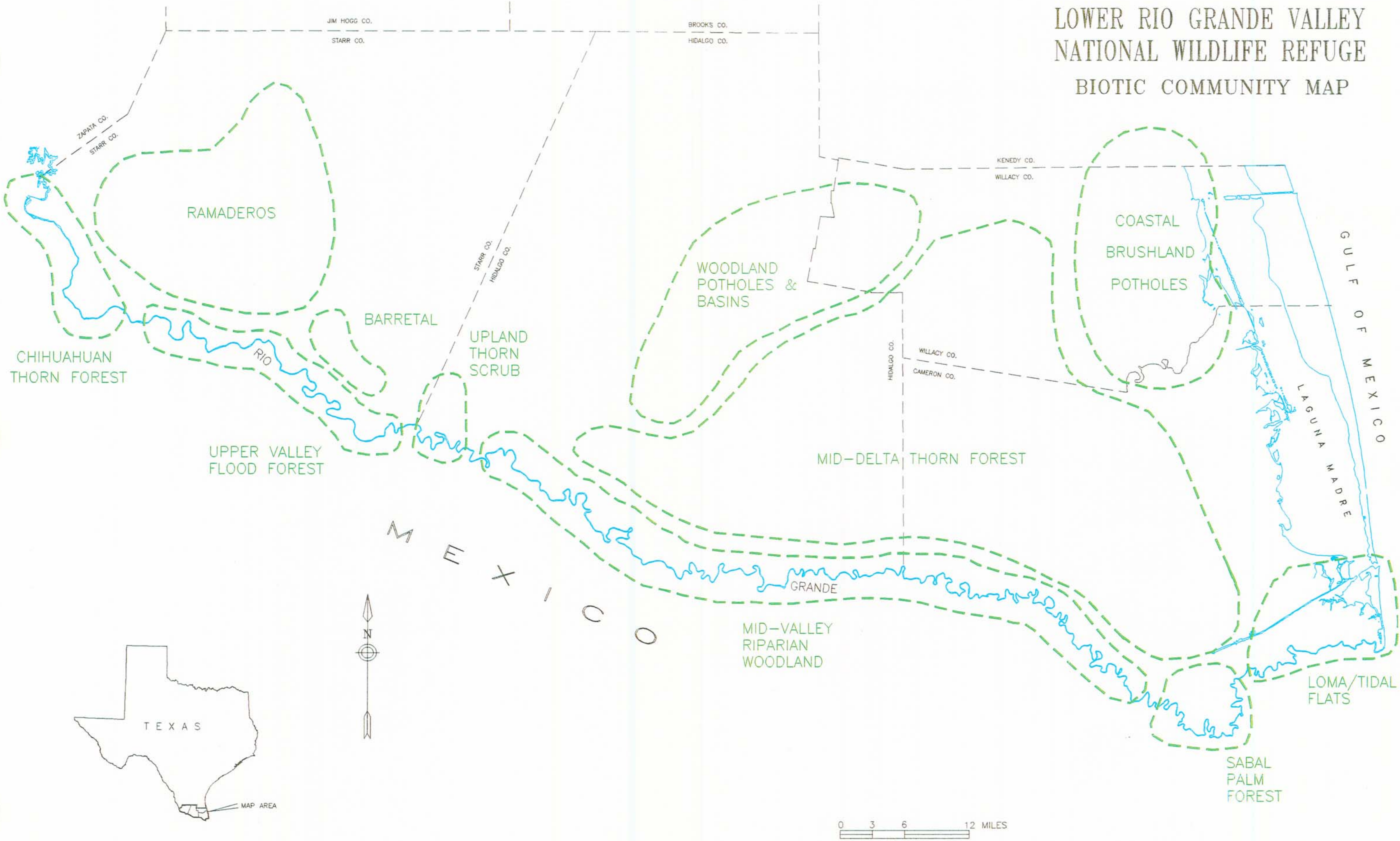


LEGEND

		Miles	(KM)
⌂	PHOTO BLIND		
	REFUGE BOUNDARY		
	SERVICE ROADS (Private Vehicles Prohibited)		
□	DESIGNATED PARKING AREA		
	REFUGE DRIVE (One Way To Traffic)	7.0	11.2
	WALKING TRAILS (Foot Traffic Only)		
	A Santa Ana (Handicapped Access)	.5	.9
	B Santa Ana Communities	1.6	2.5
	C Wildlife Management	2.0	3.2
	Cattail Trail	1.5	2.5
	Highland	.6	1.0
	Jaguarundi	1.4	2.2
	Mesquite	.3	.5
	Owl	2.0	3.2
	Resquite	1.0	1.6
	Terrace	.8	1.3
	Vireo	.9	1.4

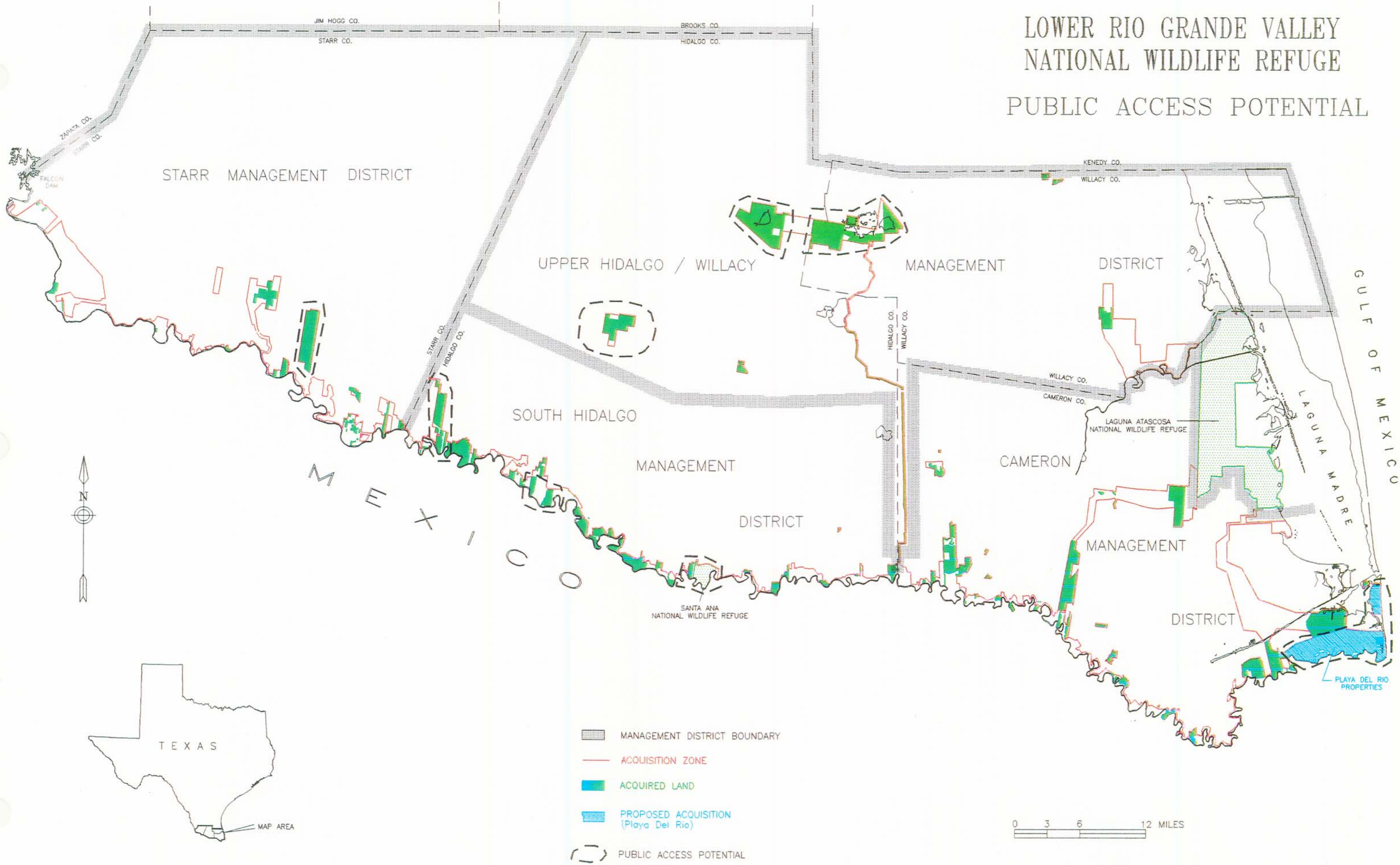
MAP: 3

LOWER RIO GRANDE VALLEY NATIONAL WILDLIFE REFUGE
BIOTIC COMMUNITY MAP



LOWER RIO GRANDE VALLEY NATIONAL WILDLIFE REFUGE

PUBLIC ACCESS POTENTIAL



MAP: 8

DEPARTMENT OF THE INTERIOR

LAND PROTECTION PLAN

LOWER RIO GRANDE VALLEY
NATIONAL WILDLIFE REFUGE

IN

CAMERON, HIDALGO, STARR, AND
WILLACY COUNTIES, TEXAS

Prepared by:
U.S. Fish and Wildlife Service
Region 2
Albuquerque, New Mexico
June 1983

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SUMMARY

The land protection plan represents the most desirable course of action to protect approximately 100,000 acres of the best remaining, threatened wildlife habitat on the American side of the Lower Rio Grande Valley (LRGV) of Texas for 115 or more vertebrate and invertebrate species; including, the white-winged dove, chachalaca, several passerine species and other migratory birds; plus numerous endangered species, such as the jaguarundi, ocelot, bald eagle, brown pelican, peregrine falcon, and Atlantic hawksbill. Maintenance of these endangered or peripheral faunal species, plus maintenance of the unique floral communities/ecosystems that are responsible for the natural occurence and distribution of those species, will eliminate the present hazard of habitat destruction (90 percent of the area has already been cleared). This protection plan is designed to preserve and enhance wildlife values in the LRGV. It calls for close cooperation between the public and private sector. Three existing national wildlife refuges are located in this area--the Santa Ana, Laguna Atascosa, and Lower Rio Grande Valley National Wildlife Refuges. This plan also involves existing State parks and wildlife management areas and private preserves operated by the National Audubon Society and other organizations.

PROPOSED:	Regional Director, Albuquerque, NM	6/29/83 Date
RECOMMENDED:	Associate Director-Wildlife Resources	Date
CONCUR:	Associate Director-Environment	Date
	Associate Director-Federal Assistance	Date

CONCUR: ______________________________ ______________

Assistant Director-Policy and Budget | Date

APPROVED: ______________________________ ______________

Director, Fish and Wildlife Service | Date

CONCUR: ______________________________ ______________

Assistant Secretary for Fish and Wildlife and Parks | Date

NEPA AND SECTION 7 DOCUMENTATION

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

Based on a review and evaluation of the information contained in the supporting references, I have determined that the habitat preservation program in the LRGV, Texas, is not a major Federal action which would significantly affect the quality of the human environment within the meaning of section 102(2)(c) of the National Environmental Policy Act of 1969.

This proposal is in compliance with Executive Order 11988, "Floodplain Management," and Executive Order 11990, "Protection of Wetlands," and section 7 documentation as required by the Endangered Species Act of 1973. Additionally, the proposal has been developed consistent with the Secretary of the Interior's new policy addressing State and Federal relationships in managing fish and wildlife resources. Accordingly, the preparation of an environmental impact statement on the proposed action is not required.

Supporting References

A land protection plan was prepared in June of 1983, and it summarizes the proposal and the environmental impacts of the proposed action. The land protection plan is on file at the U.S. Fish and Wildlife Service, Southwest Regional Office, P.O. Box 1306, Albuquerque, New Mexico 87103, and is available for public inspection upon request.

Thomas E. Smith — 6/29/83

Acting Assistant Regional Director, Wildlife Resources — Date

Conrad A. Fjetland — 6/29/83

Assistant Regional Director, Federal Assistance — Date

APPROVED BY:

M. J. Spear — 6/29/83

Regional Director — Date

I. PROBLEM/NEED

A. Problem and Major Issues

The Lower Rio Grande Valley (LRGV) falls within the Tamaulipan biotic province on the Gulf of Mexico coastal plain. The typical vegetative complex within this province is refered to as Tamaulipan thorn scrub, or simply as brush. Many soils of the Tamaulipan biotic province are fertile and eminently suitable for agricultural use after the thorn-scrub vegetation has been cleared.

Increasing pressure, principally from agricultural usage and also from urban and industrial growth, continues to rapidly convert the once extensive belt of native brush. This extensive conversion from brush has occurred on both the United States' and Mexican sides of the Rio Grande at an alarming rate (see appendix E for paper on "Revolucion Verde.")

The key decision elements associated with the LRGV are: (1) determine if the Tamaulipan thorn-scrub habitat has wildlife values worthy of preservation, (2) determine what preservation efforts would be effective in preserving existing remnants of the thorn-scrub habitat, and (3) can cleared land be re-established in thorn scrub; and, if so, what actions can be employed to incorporate revegetation into preservation plans for the LRGV.

The key decision elements relate directly to prior acquisition/protection efforts by the U.S. Fish and Wildlife Service (FWS), Texas Parks and Wildlife Department (TPWD), and private conservation organizations; such as, the National Audubon Society, World Wildlife Fund, and others. These related efforts have been documented in the following FWS publications:

1. Environmental Assessment (EA), 1974. Proposed Addition of Lands to Santa Ana National Wildlife Refuge (NWR), Texas.

2. EA, 1978. Proposed Acquisition of White-winged Dove Habitat, Cameron, Hidalgo, and Starr Counties.

3. EA, 1978. Proposed Acquisition of the La Sal Vieja NWR, Texas.

4. Habitat Preservation Plan, 1980. Preservation of Areas of Important Fish and Wildlife Habitat, Cameron, Hidalgo, Starr, and Willacy Counties, Texas.

5. Migratory Waterfowl Wetland Preservation Concept Plan for Texas Coast, Category No. 8. Completed in 1977, updated in 1981.

Additionally, TPWD has an active habitat acquisition program in the LRGV aimed at preserving nesting and fall-roosting habitat for white-winged dove. Private conservation organizations also have active preservation programs in progress in an effort to preserve as much of the remaining brush as possible in the LRGV.

B. Time Frame

The time frame is extremely urgent as conversion of the native brush is continuing at a rapid pace. In excess of 90 percent of the original habitat on the United States' side of the Rio Grande has been cleared, and the land use changed primarily to agriculture. The same trend is taking place on the Mexican side of the Rio Grande with massive clearing projects taking place to increase Mexico's food producing capabilities. In Tamaulipas, Mexico's total production (hectares) increased from 242,800 in 1953-54 to 1,310,200 in 1980-81. Most of this increase has occurred through the clearing of Tamaulipan thorn scrub.

Without intensified protection efforts, there will be very few acres of unprotected brush remaining within 5 years at the present rate of clearing. The extensive clearing now underway in Tamaulipas, Mexico, places additional emphasis and urgency on preservation efforts on the United States' side.

C. Authorities

Three NWRs located in the LRGV are: the Laguna Atascosa NWR, on the Texas coast, containing approximately 48,000 acres; Santa Ana NWR containing approximately 2,000 acres; and LRGV NWR containing approximately 4,000 acres (see table 1). The LRGV NWR is administered by FWS as part of the

Table 1.-Summary of Land Status for Santa Ana and Lower Rio Grande Valley National Wildlife Refuge Complex as of June 1983

Tract #	Tract Name	Land Acreage	Mgmt. Brush Unit	Type Acquisition
01P	IBWC	0.01	Santa Ana	License
03R	Hidalgo County	0.52	Santa Ana	Easement
04	First National Bank/Chicago	1,867.85	Santa Ana	Duck Stamp - Fee
04a-d	First National Bank/Chicago	112.65	Santa Ana	Duck Stamp - Fee
04e,f-I	First National Bank/Chicago	37.06	Santa Ana	LWCF - Fee
11	Murphy, Lois Brewster	24.00	Santa Ana	LWCF - Fee
12	Valdez, Ramon	3.56	Santa Ana	LWCF - Fee
13	Bravo, Jose A. et al.	14.08	Santa Ana	LWCF - Fee
14	Schuster, Carl F. et ux.	14.07	Santa Ana	LWCF - Fee
14a	Schuster, Carl F. et ux.	0.37	Santa Ana	LWCF - Fee
15	Vasquez, Guadalupe	7.12	Santa Ana	LWCF - Fee
16,a	Frank Schuster Farms, Inc.	4.169	Santa Ana	LWCF - Fee
16b	Frank Schuster Farms, Inc.	2.30	Santa Ana	LWCF - Fee
207	IBWC	17.40	Southmost/LRGV	Transfer
239	Clark Estate, Robert L.	30.00	Thompson Road/LRGV	LWCF - Fee
241	de la Garza, Leonel Jr. et al.	115.407	La Paloma/LRGV	LWCF - Fee
247	TNC (Taylor/Benson)	364.99	Southmost/LRGV	LWCF - Fee
317	Vela, Francisca R.	128.43	Vela Wood/LRGV	LWCF - Fee
318	Ingram, Jessie et al.	1.30	Vela Wood/LRGV	LWCF - Fee
319	Holt, Norma	16.60	Vela Wood/LRGV	LWCF - Fee
320	Cantu de Lozano Estate	17.69	Vela Wood/LRGV	LWCF - Fee
321	Richey, Florence E.	27.86	Vela Wood/LRGV	LWCF - Fee
322	Cantu, Prudencio T.	9.81	Vela Wood/LRGV	LWCF - Fee
323	Ovila, David	18.69	Vela Wood/LRGV	LWCF - Fee
326,a-c	World Wildlife Fund	1,440.18	Santa Ana/LRGV	Gift
327	IBWC	481.00	Santa Ana/LRGV	Transfer
328	Hidalgo/Willacy Countys WCID #1	24.24	Santa Maria/LRGV	LWCF - Fee
329M	Hidalgo County WID #2	425.00	Santa Ana/LRGV	Agreement
425	Garza, Fidelio Sr. et ux.	34.40	Yturria/LRGV	LWCF - Fee
430	Miller, Barbara Baldridge	34.38	Abrams/LRGV	LWCF - Fee
444	Greene, Waldo W. et ux.	49.426	Abrams/LRGV	LWCF - Fee
513	Guerra, Narciso et al.	8.33	La Grulla/LRGV	LWCF - Fee
514	Cordova, Manuel Alonzo et al.	21.77	La Grulla/LRGV	LWCF - Fee
515	Guerra, Noel et al.	8.08	La Grulla/LRGV	LWCF - Fee
517	Garcia, Eulalia S. et al.	6.20	La Grulla/LRGV	LWCF - Fee
565	Farias, Wenceslado	2.58	La Grulla/LRGV	LWCF - Fee
	Total Acres	±5,370*		

*By end of fiscal year 1983, a total of approximately 6,000 acres will be administered by FWS as part of the Santa Ana refuge complex. An additional 4,600 acres should be leased for 40 years at no cost from the Brownsville Navigation District before September 1983.

Santa Ana refuge complex. A separate land protection plan will be prepared for the Laguna Atascosa NWR in the future. Although Laguna contains some wildlife habitat that is beneficial to the 115 species discussed in this plan, it is principally a Texas coastal waterfowl refuge established by the Migratory Bird Conservation Commission (MBCC); and land protection efforts are presently monitored through the Texas coast category No. 8 wetland preservation concept plan (see figures 1 and 2 for location of LRGV refuges and management units).

In the last 40 years, FWS has acquired, and by September 30, 1983, will be managing, a total of approximately 6,000 acres of wildlife habitat in the LRGV for the Santa Ana refuge complex under the broad authority contained in the following legislation:

1. The Migratory Bird Conservation Act of 1929 (16 U.S.C. 715-715r; 45 Stat. 1222) authorizes acquisition, development, and maintenance of migratory bird refuges; cooperation with other agencies in conservation; and investigations and publications on North American birds.

   In 1942, the MBCC approved (under the authority of the Migratory Bird Conservation Act) the purchase, in fee, of three brush tracts totaling approximately 2,300 acres to establish the Santa Ana NWR. "Six-million-dollar" funds were used to acquire this land (49 Stat. 378).

2. The Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j; 70 Stat. 1119) approved August 8, 1956, and subsequently amended, established a comprehensive fish and wildlife policy and directed the Secretary to provide continuing research; extension and information services; and directed use of acquisition, management, and conservation of fish and wildlife resources.

   From 1979 to the end of this fiscal year (September 30, 1983), a total of 20 brush tracts, scattered along the Lower Rio Grande, containing approximately 3,400 acres will be added to the refuge system since establishment of the LRGV NWR on February 12, 1979, under the authority in the 1956 Act. Fee title to four tracts, containing 1,440 acres, was donated to FWS by the World Wildlife Fund. Approximately 425 acres are

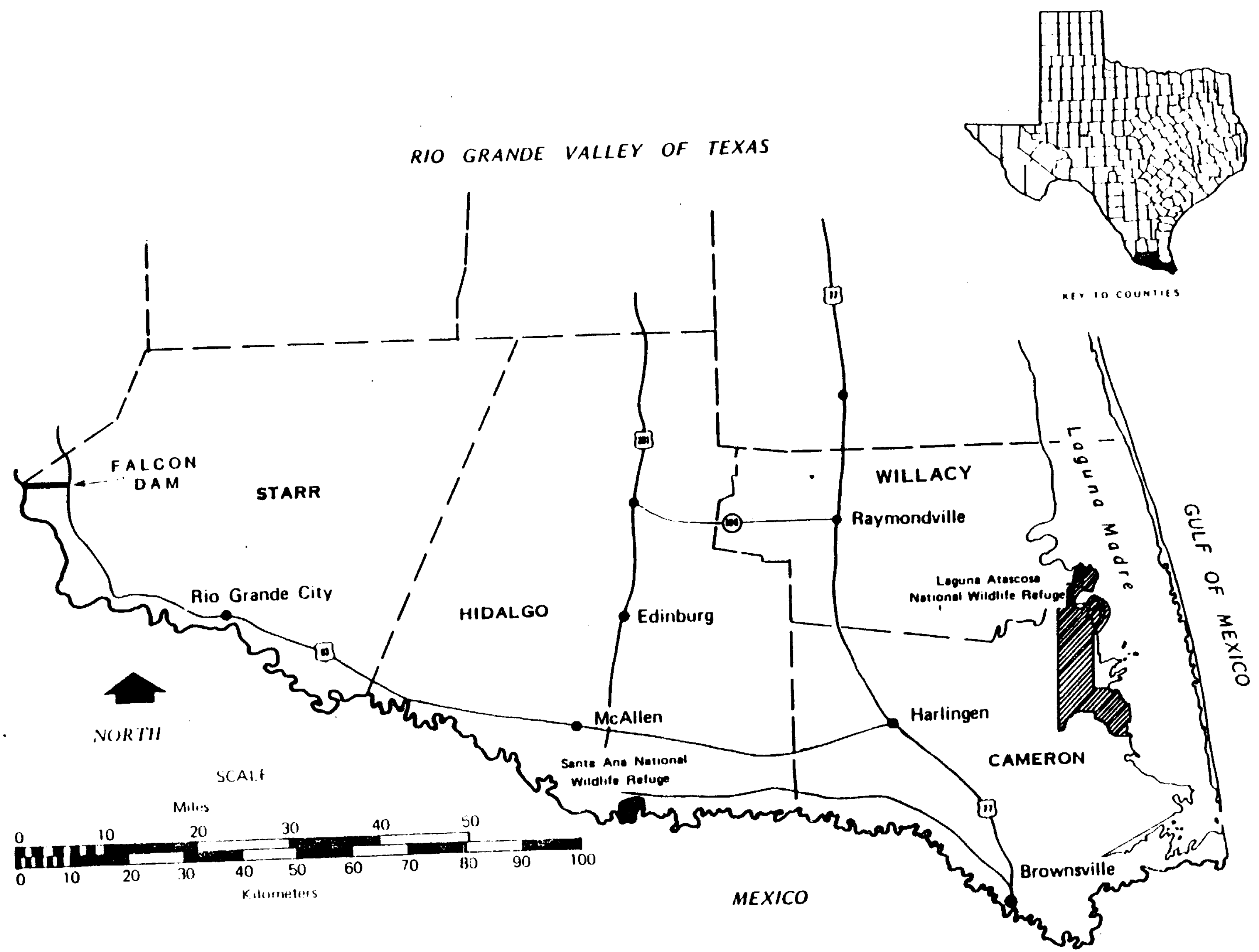

FIGURE 1: LOCATION OF THE STUDY AREA: CAMERON, HIDALGO, STARR, AND WILLACY COUNTIES, TEXAS

NATIONAL WILDLIFE REFUGES IN THE RIO GRANDE VALLEY

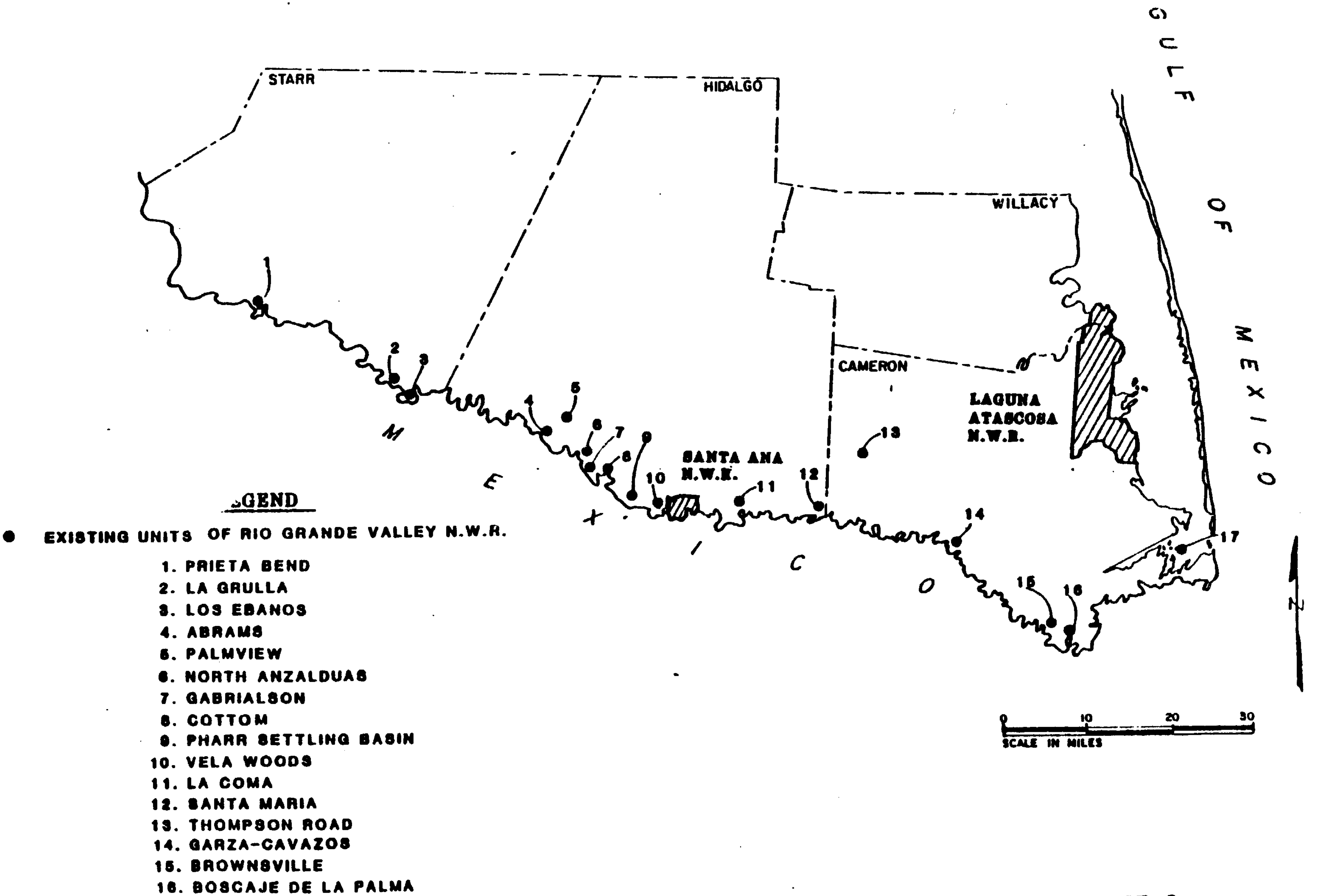

FIGURE 2:

managed by FWS under a mutually-beneficial, no-cost lease with local water districts; and 480 acres were transferred by treaty (1 U.S.C. 113; 80 Stat. 271) to FWS by the International Boundary and Water Commission (IBWC), United States and Mexico. This tract was formerly a part of Mexico, but included in the United States pursuant to an international boundary settlement along the Rio Grande. The remaining 14 brush tracts, containing 1,055 acres, were acquired in fee title by FWS under the authority in the 1956 Act using the Land and Water Conservation Fund (LWCF).

3. The Refuge Recreation Act of 1962 (16 U.S.C. 460k-460k-4; 76 Stat. 653) authorizes appropriate, incidental or secondary recreational use and acquisition of conservation areas administered by the Secretary for fish and wildlife purposes.

   From 1975 to 1978, fee title to 14 small brush tracts--totaling approximately 300 acres, and ranging in size from 0.37 acres to 128 acres--were acquired by FWS along the Rio Grande as recreational additions to the Santa Ana NWR. LWCF funds were used for these purchases as authorized under the 1962 Act.

Major constraints--resulting in lack of past success in preservation of wildlife habitat in the LRGV--historically centered on insufficient, unstable funding sources for acquisition and management; land title problems in the flood plain along the river corridor, which contains Spanish land grants dating back to the early 1500's (title insurance is still not available for some tracts in the Falcon Woodlands area in Starr County); difficulty locating and communicating with property owners (approximately 85 percent of the population in the LRGV is of Hispanic origin); and the small size and wide dispersion of the remaining wildlife habitat remnants located throughout the 250-river-miles area from Falcon Dam to the Gulf of Mexico.

Until the Fish and Wildlife Act of 1956 was amended in the late 1970's, it was very difficult to obtain acquisition funding for the LRGV area. Migratory bird "duck stamp" funds, by policy, are normally spent by FWS only on the highest priority waterfowl areas, not refuges utilized principally by wildlife including migratory birds and endangered plant and vertebrate species other than waterfowl. Most FWS LWCF money normally goes for acquisition of specially legislated refuges and purchase of critical habitat for endangered species.

The availability of approximately $1,000,000 of LWCF money in the FY83 budget for the LRGV NWR has finally made it possible for FWS to initiate a major preservation effort to protect these important brushland tracts in the LRGV. See appendix A for status report on FY83 land acquisition. Many landowners are now contacting FWS and TPWD expressing an interest in selling their brushlands. FWS success in the future on land protection efforts will be dependent on receiving a stable funding source for the LRGV project, especially in FY84-89.

II. PROGRAM OBJECTIVES

A. Major Resource Values

The vegetation of the LRGV is representative of the Tamaulipan biotic province, as delineated by Blair (1950). Blair described the area as follows:

> Thorny brush is the predominant vegetation type of the Tamaulipan province of Texas. This brushland stretches from the Balcones fault line southward into Mexico. From the coast westward the brush thins out as available moisture declines. A few species of plants account for the bulk of brush vegetation and give it a characteristic aspect throughout the Tamaulipan of this state. The most important of these include (scientific names of plants as revised by Correll and Johnston, 1970): mesquite (Prosopis glandulosa), various species of Acacia and Mimosa, granjeno (Celtis pallida), guayacan (Porlieria angustifolia), cenizo (Leucophyllum frutenscens), and white brush (Aloysia gratissima), prickly pear (Opuntia engelmannii), tasajillo (Opuntia leptocaulis), and Condalia and Castela. The brush on the sandy soils differs in species and aspect from that of clay soils. Mesquite, in an open stand and mixed with various grasses, is characteristic of sandy areas. Clay soils usually have all the species listed above, including mesquite.

The study area, which the land protection plan encompasses, is composed of Cameron, Willacy, Hidalgo, and Starr Counties in the LRGV of Texas (see figure 1), an area which Blair (1950) delineated as the Matamoran District of the Tamaulipan biotic province. Blair described the Matamoran District as follows:

> The southern part of the province is poorly drained . . . The brushlands of the Lower Rio Grande Valley, in Cameron, Willacy, Hidalgo, and Starr counties, are more luxuriant than the brushlands farther south, and they are characterized by the predominance of several species of plants that decrease in abundance northward. The most important of these species include: retama (Parkinsonia aculeata), Texas ebony (Pithecellobium flexicaule), anacahuita (Cordia boissieri), and anacua (Ehretia anacua). The most luxuriant brush occurs on the immediate flood plain of the lower Rio Grande. Large elms (Ulmus crassifolia) dominate the flood plain in some places, and there is usually an alteration of elm dominants and brush species.

The fauna of the Matamoran District is comprised of approximately 525 vertebrate species; and within this district, for the purposes of this plan, 10 vegetative communities have been delineated which are known to provide vital habitat components for these vertebrate species. The 10 vegetative communities are identified and described as follows:

1. Chihuahuan Thorn Forest

This is a desert shrub community which includes a riparian zone along the Rio Grande just below Falcon Dam. The riparian zone varies in width from a steep bank or bluff to a flood terrace one-quarter mile in width. The unique feature of this community is the riparian zone and its ecotone with the river on one side and desert shrub on the other. The riparian zone includes black willow (Salix nigra), Montezuma cypress (Taxodium mucronatum), Texas ebony (Pithecellobium flexicaule), and mesquite (Prosopis glandulosa). The upland has sotol (Dasylirion texanum), catclaw mimosa (Mimosa biuncifera), and black-brush (Acacia rigidula). This is a well-publicized birding area known nationally for the brown jay (Psilorhinus morio), all three kingfishers, and the ferruginous pygmy owl (Glacidium brasilianum). The area is noted elsewhere in this report as the Falcon woodlands, which ranked No. 5 on a national scale for unique and valuable ecosystems. This community includes the upper, middle and lower Falcon woodland ecological units listed in the corridor concept (figure 3).

2. Upper Valley Flood Forest

This community designation is used to distinguish the small forested valleys of the Rio Grande, between Falcon and Mission, from the deltaic woodlands further downstream. There are four ecologic units (figure 3) which are included in this classification. Each of these has its own unique wildlife values. For example, one of the proposed units, Los Adjuntos, is at the confluence of the Rio San Juan and the Rio Grande. The meeting of these two natural wildlife corridors has obvious wildlife importance. All four units share important wildlife values--one being traditional roosting areas for fall feeding flights of white-winged dove production as well as being suitable habitat for many of the species of management concern for this refuge (tables 2 and 3). Mesquite and granjeno (Celtis spinosa) are representative woody species.

LOWER RIO GRANDE VALLEY NATIONAL WILDLIFE REFUGE

LAND PROTECTION PLAN

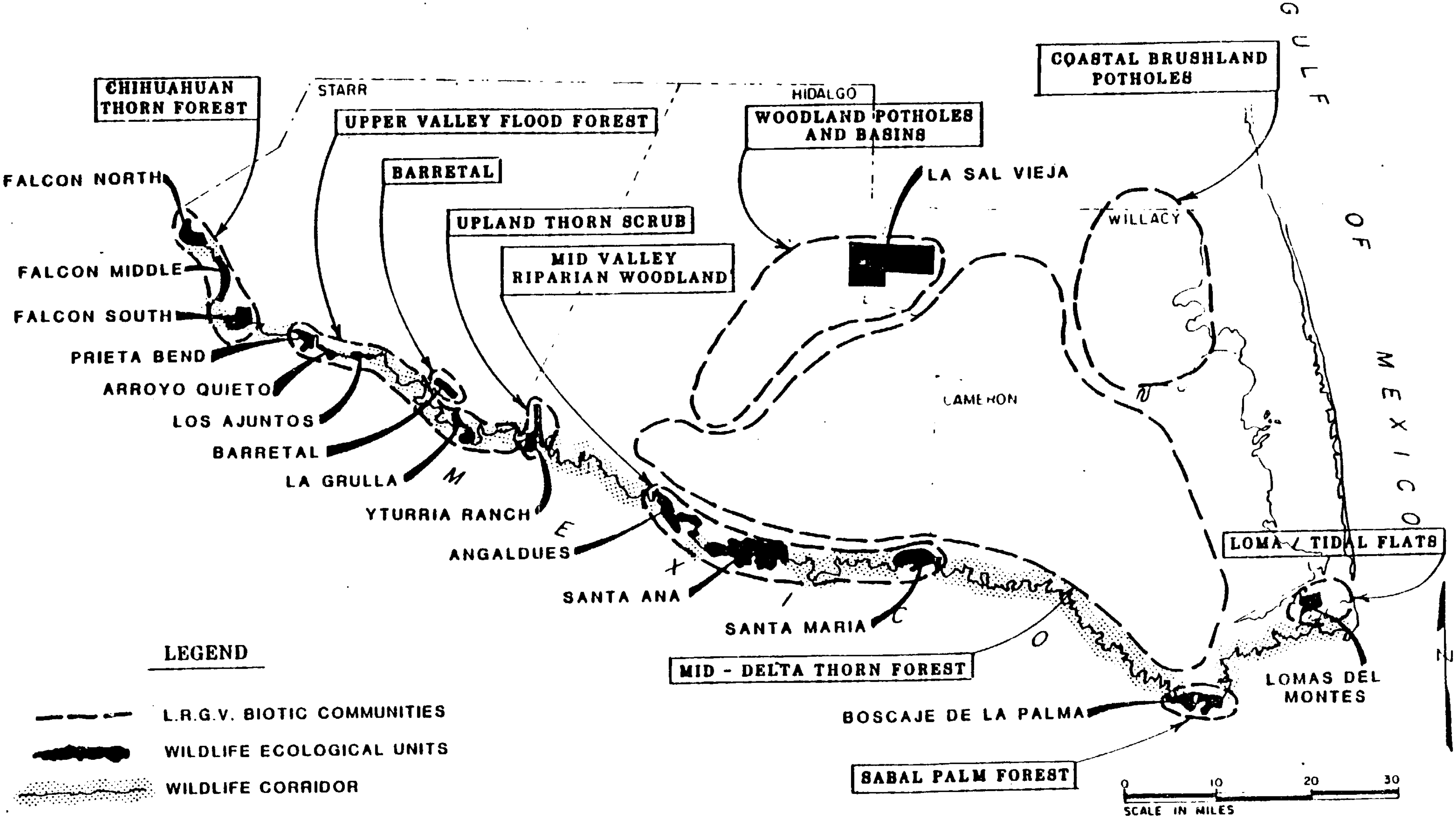

FIGURE 3:

Table 2.-Endangered, Threatened, or Peripheral Vertebrates of Actual or Potential Occurrence in the Lower Rio Grande Basin Study Area

Common Name	Scientific Name	USDI[1]	TOES[2]	TPWD[3]
Southern yellow bat	Lasiurus ega		P	NG
Coati	Nasua narica		P	
Mountain lion	Felis concolor		T	
Ocelot	Felis pardalis	E	E	E
Jaguarundi	Felis yagouaroundi	E	E	E
Coue's rice rat	Oryzomys couesi		T	
Bottle-nosed dolphin	Tursiops truncatus		T	
Brown pelican	Pelecanus occidentalis	E	E	E
Reddish egret	Dichromonassa rufescens		E	NG
White-faced ibis	Plegadis chihi		T	NG
Wood stork	Mycteria americana			NG
Roseate spoonbill	Ajaia ajaja		P	
Fulvous whistling duck	Dendrocygna bicolor		T	
Masked duck	Oxyura dominica		P	
White-tailed kite	Elanus leucurus		P	
Swallow-tailed kite	Elanoides forficatus		T	NG
Zone-tailed hawk	Buteo albonotatus		P	NG
Gray hawk	Buteo nitidus		P	NG
White-tailed hawk	Buteo albicaudatus		P	NG
Black hawk	Buteogallus anthracinus		P	NG
Bald eagle	Haliaeetus leucocephalus	E	E	E
Golden eagle	Aquila chrysaetos		T	
Osprey	Pandion haliaetus			NG
Peregrine falcon	Falco peregrinus	E	E	E
Prairie falcon	Falco mexicanus		T	
Merlin	Falco columbarius		T	
Sooty tern	Sterna fuscata		P	
Least tern	Sterna albifrons		T	NG
Black skimmer	Rhyncops niger		T	
Jacana	Jacana spinosa		T	
Red-billed pigeon	Colomba flavirostris		T	
Ferruginous owl	Glaucidium brasilianum		P	NG
Ringed kingfisher	Megaceryle torquata		P	
Rose-throated becard	Platypsaris aglaiae		P	

Table 2.-Continued

Common Name	Scientific Name	USDI[1]	TOES[2]	TPWD[3]
Beardless flycatcher	*Camptostoma imberbe*		P	
Brown jay	*Psitorninus morio*		P	
Yellow-green vireo	*Vireo flavoviridis*		P	
Tropical parula	*Parula pitiyuma*		P	
Botteri's sparrow	*Aimophila botterii*		T	
Altamira oriole	*Icterus gularis*		P	
Mexican burrowing toad	*Rhinophrynus dorsalis*		P	NG
Giant toad	*Bufo marinus*		P	NG
Rio Grande frog	*Syrrhophus cystignathoides campi*		P	NG
Mexican white-lipped frog	*Leptodactylus labialis*		P	NG
Mexican tree frog	*Smilisca baudini*		P	NG
Black-spotted newt	*Notophthalmus meridionalis*			NG
Rio Grande siren	*Siren intermedia texana*		T	NG
American alligator	*Alligator mississipiensis*	T/E	E	NG
Atlantic or Kemp's Ridley turtle	*Lepidochelys kempi*	E	E	E
Atlantic leatherback	*Dermochelys coriacea*	E	E	E
Atlantic loggerhead turtle	*Caretta caretta*	T	T	NG
Atlantic green turtle	*Chelonia mydas*	T	T	NG
Atlantic hawksbill	*Eretomochelys imbricata*	E	E	E
Texas tortoise	*Gopherus berlandieri*	–	T	NG
Reticulate collared lizard	*Crotaphytus reticulatus*		T	NG
Texas horned lizard	*Phrynosoma cornutum*		T	NG
Black-striped snake	*Coniophanes imperialis*		P	NG
Speckled racer	*Drymobius margaritiferus*		P	E
Northern cat-eyed snake	*Leptodeira septentrionalis*		P	NG
Texas indigo snake	*Drymarchon corais*		P	NG
Mexican milk snake	*Lampropeltis triangulum annulata*		T	NG
Proserpine shiner	*Notropis proserpinus*			NG

1. Endangered (E and T), according to the U.S. Department of the Interior (1977 and numerous other listings).

2. Endangered (E), threatened (T), or peripheral (P) in Texas according to the Texas Organization for Endangered Species (1979).

3. Endangered (E) or protected nongame (NG) species in Texas according to Texas Parks and Wildlife Department (1977).

Table 3.-Additional Species of Management Concern
Particular to Lower Rio Grande Valley National Wildlife Refuge

Common Name	Scientific Name	Classification
Hook-billed kite	*Chondrohierax unicinatus*	P
Plain chachalaca	*Ortalis vetula*	P
White-winged dove	*Zenaida asiatica*	P
White-tipped dove	*Leptotila verreauxi*	P
Couch's kingbird	*Tyrannus couchii*	P
Great kiskadee	*Pitangus sulphuratus*	P
Green jay	*Cyanocorax yncas*	P
Olive sparrow	*Arremonops rufivirgatus*	P
Clay-colored robin	*Turdus grayi*	P
Black-headed oriole	*Icterus graduacauda*	P
White-collared seedeater	*Sporophila torqueola*	P
Mottled duck	*Anas fulvigula*	P
Black-bellied whistling duck	*Dendrocygna autumnalis*	P
Pintail	*Anas acuta*	W
Ruddy duck	*Oxyura jamaicensis*	W
Lesser scaup	*Aythya affinis*	W
Blue-winged teal	*Anas discors*	W
Green-winged teal	*Anas crecca*	W
Northern shoveler	*Anas clypeata*	W
Least grebe	*Podiceps dominicus*	P
Eared grebe	*Podiceps nigrocellis*	W
Bronzed cowbird	*Tangavius aeneus*	P
Groove-billed ani	*Crotophaga sulcirostris*	P
Great-tailed grackle	*Quiscaulus mexicanus*	P
Mexican crow	*Corvus imparatus*	P
Long-billed thrasher	*Toxostoma longirostre*	P
Buff-bellied hummingbird	*Amazilia yucatanesis*	P
Pauraque	*Nyctidromus albicollis*	P
Broad-winged hawk	*Buteo platypterus*	MR
Swainson's hawk	*Buteo swainsoni*	MR
Harris hawk	*Parabuteo unicinctus*	P
Caracara	*Caracara cheriway*	P
Elf owl	*Micrathene whitneyi*	P

Table 3.-Continued

Common Name	Scientific Names	Classification
Green kingfisher	*Chloroceryle americana*	P
Brown-crested flycatcher	*Myiarchus tyrannulus*	P
Olive-backed warbler	*Parula pitiayumi*	P
Hooded oriole	*Icterus cucullatus*	P
White pelican	*Pelecanus erythrorhynchos*	WB
Sandhill crane	*Grus canadensis*	GS
Olivaceous cormorant	*Phalacrocorax olivaceus*	P
Bobwhite	*Colinus virginianus*	GS
Scaled quail	*Callipepla squamata*	GS
Collared peccary	*Pecari tajuca*	GS
White-tailed deer	*Odocoileus virginianus*	GS
Bobcat	*Lynx rufus*	PS
Cottontail	*Sylvilagus floridanus*	GS
Mesquite lizard	*Sceloporus gramniens*	P
Ruthven's whipsnake	*Masticophis taeniatus*	P
Coyote	*Canis latrans*	PS
Mourning dove	*Zenaida macroura*	GS
Redhead	*Aythya americana*	W
Canvasback	*Aythya valisineria*	W
Chihuahuan raven	*Corvus cryptoleucus*	P

P = peripheral
W = waterfowl
MR = migrating raptor
WB = water bird
GS = game species
PS = predator species

3. Barretal

The barretal is the baretta (Helietta parvifolia) community. This area is roughly bounded by Highway 83 on the north, the road to La Grulla on the east, the old military highway on the south, and the town of La Puerta on the west. The proposed unit is the only site in the United States where this tree (a native citris) occurs as a thicket or "barretal." The distribution of this tree in the United States is restricted to a narrow band of gravel and caliche ridges which form an ecotone with the flood plain. The barretal also happens to be located in prime habitat for the elf owl (Micrathene whitneyi), the reticulated collard lizard (Crotaphytus reticulatus), and the burrowing toad (Rhinophrynus dorsalis).

4. Upland Thorn Scrub

Surrounding the Rio Grande's delta and river valleys within the Tamaulipan biotic province is the upland thorn forest. This is the more ubiquitous habitat type in the province. A small representative tract was delineated because of its position relative to the Rio Grande. This unit (figure 3) functions as a wildland corridor connecting the riparian habitats with the uplands. This site is the first significant block of upland habitat encountered on the west edge of the delta. Land on either side has already been cleared for dryland agriculture. This particular tract is heavily used by migrating raptors, particularly Swainson's hawks (Buteo swainsoni) and broad-winged hawks (Buteo platypterus), both of which migrate through the LRGV in spectacular numbers. Typical woody plants are the anacahuita (Cordia boissieri) and cenizo (Leucophyllum violaceum).

5. Mid-Valley Riparian Woodland

This community is essentially a bottomland hardwood site. Throughout the community are stands of cedar elm (Ulmus crassifolia), Berlandier ash (Fraxinus berlandieriana), sugar hackberry (Celtis laevigata), mixed in with a mesquite/granjeno association. As would be expected in a bottomland site, the result is a dense, tall, canopied forest. Here is the preferred habitat for many rare avian species. A greater availability of water and food is another characteristic of these riparian sites. Orioles, chachalacas (Otalis vetula), and green jays (Cyanocorax yncas) may reach their greatest density in these sites. Another important factor is that here is where many of the "resacas" or old oxbow lakes are found. Each of these miniature aquatic ecosystems protect a unique group of Tamaulipan biota.

6. Sabal Palm Forest

This community is also referred to as Boscaje de la Palma. It is the easternmost wildlife ecological unit identified in figure 3. Boscaje de la Palma is located in the southmost bend of the Rio Grande just downstream from Brownsville. The remnant stands of palms found throughout the 3,500-acre identified area represent what is left of what once was a 40,000-acre palm-dominated community. Boscaje de la Palma is the northernmost of a series of palm forests or jungles extending along the gulf coast primarily in the Mexican state of Tamaulipas. Agricultural clearing has caused the demise of most of these palm jungles. In 1980, there were still several located near Soto la Marina in Tamaulipas. The palm remnants located at Boscaje de la Palma are best described as palm-dominated brush tracts with the sabal palm, tepeguaje, anaqua, and Texas ebony being major woody associates. Characteristic fauna of special concern to FWS include ocelot, jaguarundi, yellow bat, hooded oriole, speckled racer, and northern cat-eyed snake.

7. Clay Loma/Wind Tidal Flats

Here we are actually dealing with three different communities which together form a miniature ecosystem--wooded islands located in a tidal flat periodically inundated by water from South Bay and the gulf. The heart of this wildlife ecological unit is the approximately 4,600-acre loma preserve leased from the Brownsville Navigation District. Another 5,000 to 6,000 acres are needed to complete this unit (figure 3) because South Bay is the source of water for the hydrology of the system. The lomas are formed from wind-blown silt or clay particles originally deposited in the tidal flats by periodic flooding from the Rio Grande. When the flats are dry and barren of vegetation, prevailing winds pick up the particles and deposit them on the dunes which are normally covered with woody vegetation. Some of these dunes have grown to an elevation of 30 feet above the surrounding tidal flats. When the flats are vegetated or flooded, rains and flooding erode the outer edges of the lomas. When the wind or storm tides retreat, the loma building begins again. Characteristic vegetation includes fiddlewood (Citharexylum brachyanthum) and Texas ebony (Pithecellobium flexicaule) on the lomas; borrichia (Borrichia frutescens), and salicornia (Salicornia spp.) on the flats; and black mangrove (Avicennia nitida) on South Bay. Representative vertebrates are Texas tortoise (Gopherus berlandieri), long-billed curlews (Numenius americanus), and a unique hypersaline-tolerant population of oysters (Ostrea equestris).

8. Mid-Delta Thorn Forest

This community is comprised of a mesquite/granjeno association mixed with ebony, anaqua (Ehretia anacua), brazil (Condalia hookeri), and others and was once an extensive thicket that covered most of the Rio Grande delta or "valley." There is less than 5 percent of this habitat left, and most of that is in fence rows, highway right-of ways, canals, and ditch banks. Here the thicket forms a tight interwoven canopy about 15 to 20 feet high. This was the historic nesting habitat of the white-winged dove. The remnant tracts are usually quite small in size, normally less than 100 acres.

Because of this scarcity and because of the scattered nature of this community or habitat type, we are pursuing an island philosophy as opposed to trying to preserve one or more large units (there just are not any large tracts left). Other major considerations of value in the island approach are the maintenance of a diverse gene pool and as a refuge for the production of pioneering populations of native plants and animals in order to continue to replace catastrophic losses when other lands are cleared or burned.

9. Woodland Potholes and Basins

This community includes the salt lakes of the proposed La Sal Vieja National Wildlife Refuge which are hypersaline due to evaporation and inflow from underground salt springs. The twin lakes of La Sal Vieja are the best example of this physiological feature. They are surrounded by brushlands which, again, include many small wetlands or potholes. These are freshwater wetlands. Some are resacas or old river channels, and many are shallow basins, perhaps a result of a more arid period when winds caused "blow-outs" in the sandy soil formations. These wetlands are often dry; but during wet seasons they are very productive, and during wet winters they function as green tree reservoirs.

10. Coastal Brushland Potholes

This community is separated from the others because of the coastal influence. The wetlands vary from freshwater ponds to brackish pools to saline estuaries. The vegetation also varies because of the saline influences and because of proximity to the gulf where the micro-climate is more stable than inland. There are more days of cloud cover, more precipitation, and fewer extremes in temperature. In some areas, the topography is also impacted by sand dunes moving through the brushland. The leading edge buries the forest while the trailing edge uncovers. As these sand-dune trains move through, depressions are sometimes formed. When these areas are wet, they receive heavy use by waterfowl and other wetland species. This community also functions as a coastal corridor and may : prime habitat for the endangered ocelot and jaguarundi.

Tables 2 and 3 list 115 target species upon which this plan will focus in land (wildlife habitat) protection efforts. These species are considered those for which immediate protection efforts are required based on current biological knowledge of the Matamoran District (Cameron, Willacy, Hidalgo, and Starr Counties). In providing land protection for the 10 community types listed previously, it is felt that the continued existence of these 115 target species can be realized, while additionally assuring that the longer list of vertebrate species (525) are not extirpated.

Threatened and Endangered Faunal Species

At present, the LRGV is home or serves as a migratory stopover for three endangered species, one of which, the peregrine falcon, is endangered in the United States. Two endangered cats, the ocelot (*Felis pardalis*) and jaguarundi (*F. yagouroundi*) occur in small numbers. Population estimates for these species are unavailable due to the infrequency of observations.

Eight other species listed as either threatened or endangered by FWS potentially occur in the LRGV of Texas (table 2). With the exception of the sea turtles, all species are recorded as occurring, at least on a transient basis, in the LRGV. Table 2 also shows 9 species listed as endangered and 30 species as protected nongame by TPWD; 59 species are listed as either endangered, threatened, or peripheral by the Texas Organization for Endangered Species (TOES). Most of these species are known to occur within the vegetative communities being considered for preservation.

Threatened and Endangered Floral Species

At present, no plant species in the LRGV are considered as threatened or endangered by FWS, although TOES and the Texas Rare Plant Study Center (RPSC) have compiled lists of species which they consider to be in need of protection. This list prepared by RPSC for the four-county area is published in the "Federal Register" (see table 4).

Recreation

These lands are important to the wildlife species associated with the brush but also to the local economy of the four-county area. Recent figures show that white-winged dove hunting provides over $20 million annually to the local economy. In addition, a large number of people are attracted to native brushland and its associated wildlife. For example, Santa Ana and Laguna Atascosa NWRs and Bentsen State Park attract approximately 300,000 visitors annually, and along with other visitors to the four counties, provide nearly $350 million to the local economy.

B. National or Regional Objectives

All or portions of the LRGV have been identified in a number of FWS national objectives or preservation goals in recent years, including:

1. Top 100 Nationally Significant Fish and Wildlife Areas (FWS, 1977).

   (a) La Sal Vieja ranked number 4 nationally - included Salt Lake, pothole and brushlands around La Sal Vieja and Tres Corrales area.

   (b) Falcon Woodlands ranked number 5 nationally - included brushland along river corridor flood plain below Falcon Dam.

   (c) Southmost Ranch ranked number 42 nationally - Tropical Palm Forest.

2. FWS Important Resource Problems (IRP's)

   The Texas gulf coast ranked number 4 nationally for preservation of migratory birds and endangered species in this 1978 study - included potholes and coastal marshes in Cameron and Willacy Counties in LRGV.

3. FWS 33 Categories or Areas of National Importance to Migratory Waterfowl in the United States.

   (a) Texas gulf coast ranked number 8 - concept plan prepared by the region included potholes and coastal marshes in Willacy and Cameron Counties.

   (b) Remainder of the LRGV was included in National Waterfowl Category Number 23.

4. A number of important small wildlife areas located throughout the LRGV have been identified for preservation by local conservation groups, and personnel of TPWD, Pan American University, and FWS staff from Santa Ana refuge complex.

5. The LRGV NWR was ranked very high nationally for preservation by members of the environmental community in testimony before Congress on the fiscal year 1984 FWS budget.

In summary, a number of national and regional FWS objectives will be met in carrying out the methods of preservation recommended in this plan for the LRGV. Other ongoing studies, such as recovery plans for several endangered species--including the elusive jaguarundi and ocelot in south Texas--plus the update of the "Texas Coast Migratory Waterfowl Concept Plan" will complement and amplify national fish and wildlife program objectives and major resource values.

C. Project Objectives

The primary objective of the LRGV NWR is the maintenance of the existing wildlife population listed in tables 2 and 3 and the preservation of existing remnants of important wildlife habitat in the LRGV of Texas without extirpation or extinction of any of a longer list of vertebrate species. The accomplishment of this objective is based on a biological ascertainment strategy which consists of the following steps:

1. Identification of floral, faunal, and ecological values (see part 2, section A).

2. Breakdown of the project area into broad wildlife habitat categories using recognized ecological approaches; i.e., concepts such as barriers, corridors, islands, etc.

3. Refinement of the broad categories into the 10 biological communities, which are recognizably distinct due to vegetation, topography, wildlife use, or other accepted parameters.

4. Further refinement consisting of identifying wildlife ecological units located within each of the described communities. Each ecological unit is to provide the minimum amount of food, water, and cover necessary to

provide the life requirements for a maximum number of those previously listed 115 target species.

5. Identification of those small islands of habitat outside of any corridor which have high intrinsic value despite their small size (example: white-winged dove nesting colonies). These islands were then included in one or more of the 10 biological communities.

6. In order to minimize the total land area affected by the project, a thin corridor along the north bank of the Rio Grande is proposed to link up proposed wildlife ecological units (figure 3), thereby decreasing the total acreage necessary to maintain the wildlife integrity of the LRGV.

Objective level of habitat preservation, for the LRGV, is 107,500 acres identified to date. Of this 107,500-acre objective level, 6,000 acres will be protected through FWS acquisition by September 30, 1983. The objective level is delineated by LRGV vegetative communities with the current estimated level, objective level, and deficit as follows:

R.G.V. Communities	Current Estimated Level	Objective	Deficit
Sabal palm forest	367 ac.	3,500 ac.	-3,133 ac.
Loma/tidal flats	-0- ac.	10,000 ac.	-10,000 ac.
Chihuahuan thorn forest	-0- ac.	24,000 ac.	-24,000 ac.
Upper valley flood forest (white-winged roosting habitat)	111 ac.	10,000 ac.	-9,889 ac.
Barretal	240 ac.	5,000 ac.	-4,760 ac.
Upland thorn scrub	-0- ac.	2,000 ac.	-2,000 ac.
Mid-valley riparian woodland	5,153 ac.	13,000 ac.	-7,847 ac.
Mid-delta thorn forest	129 ac.	10,000 ac.	-9,871 ac.
Woodland potholes and basins	-0- ac.	20,000 ac.	-20,000 ac.
Coastal brushland potholes	-0- ac.	10,000 ac.	-10,000 ac.
Total all communities	6,000 ac.	107,500 ac.	-101,500 ac.

The community approach is necessary in order to separate the major wildlife/wildland resources in the LRGV. Each of these are unique and of almost equal importance in the protection of the Tamaulipan biota.

The objective is to protect in perpetuity the remaining 100,000± acres identified. The identification or ascertainment of these lands will be in accordance with the concepts of zoogeography through the utilization of corridors, natural barriers (e.g., tidal flats surrounding the lomas) and islands of sufficient size for maintenance of species diversity. A second part of the objective is to maintain and enhance those lands under refuge control for the above species through sound application of wildlife management principles such as: (1) the impoundment of water in resacas for the purpose of replicating aquatic ecosystems that were formerly maintained by flooding; (2) the possible use of prescribed burning in the palm grove if further research indicates such treatment would benefit target species; (3) the use of continuous grazing to speed woody invasion on selected tracts and to reduce fuel loads on early succession tracts; (4) the practice of mechanical reforestation to include gravity irrigation; (5) application of timber-stand improvement techniques to adjust specific habitats for favorable response of target species; (6) the acceleration of ongoing inventory through computer assistance to identify wildlife needs and to plan management strategies that will enable the refuge to accommodate new acquisitions as well as to understand existing habitats (see table 5).

The identified output associated with the objective will be the maintenance of floral and faunal species which are endangered or peripheral, and maintenance of the unique plant communities, vegetational stands and ecosystems that are responsible for the natural distribution of those species.

This proposed habitat preservation effort is an integral part of the "planning needs assessment" developed in May 1983 for the LRGV NWR (see appendix C).

Table 5.-Proposed Ranking System for Individual Tracts Within the Lower Rio Grande Valley Ecosystem

Biological-Ecological Units	
Climax vegetation	2 points
Ecological wholeness; i.e., pond with surrounding upland	1 point
Juxtaposition	1 point
Successional vegetation of sufficient quality to attract use by peripheral and/or target wildlife species	1 point
Historic use by wildlife species of concern	1 point
Maximum	5 points
Threat of Destruction Input	
Immediate - existing plan or intension	4 points
Near future - owners plan to clear or dispose of property within the next several years	3 points
Continuing - no plan; however, present market favors clearing	2 points
Distant - tract already cleared, remaining threat is by developers	1 point
Maximum	4 points
Availability Input	
Immediate and willing	4 points
Willing if offer is attractive	3 points
Not at present, maybe later	2 points
Not Interested, but not hostile	1 point
Maximum	4 points
Potential Use Input	
Multiple wildlife use to a significant degree; i.e., nesting, roosting, feeding	2 points
Ability to implement alternative management practices; i.e., ability to control water or otherwise manipulate habitat to a significant degree, boundaries easily recognized	2 points
Limited due to size, access, location, lack of water, prior easements, etc.	1 point
Potential for enhancing other refuge goals; i.e., transferable water rights	1 point
Maximum	5 points

III. RESOURCE PROTECTION ALTERNATIVES REVIEWED

A. No Action

It is possible to preserve r tural habitats by local or State zoning, ordinances, or regulations; but, within the four-county area in the LRGV study area, no public enforcement agency has police powers in this regard. In Texas, the State legislature has not enacted legislation to grant counties zoning authority, only certain cities and towns. Based on public attitude in the State of Texas, it is very unlikely counties will receive rural zoning authority in the forseeable future. A recent regional planning and development map for the LRGV classifies the natural brushland habitat as "wasteland."

The U.S. Army Corps of Engineers (Corps), through the regulatory authority of section 404 of the Federal Water Pollution Control Act of 1972 and section 10 of the Rivers and Harbors Act of 1899, requires permits for the placement of dredge or fill material into streams, lakes, and wetlands, or placement of any structure in major waterways that would affect navigation. These regulatory authorities will not serve to protect most of the areas identified in this plan for preservation since the brushlands are principally upland habitats, even those located within the flood plain along the Rio Grande. The major activities occurring in flood plains and wetlands of the LRGV are also not subject to these rules since normal agricultural practices and clearing are exempted from the permitting process. The coastal wetlands located near Brownsville could receive some protection under the Corps' permitting process, but this area represents a very small part of the study or proposed refuge.

In 1981, the Texas legislature revised section 23.83(e) of the property tax code authorizing landowners to create a voluntary deed restriction for land dedicated for recrea: :nal, park, and scenic uses. This tax deferral or open-space designation automatically expires per terms of the deed restriction. Further, to qualify, a landowner could still clear brushlands so long as the property is not used for commercial purposes.

Use of mutually-beneficial cooperative agreements providing coordination of oversight or technical wildlife assistance to landowners offers some potential and is being actively explored with larger property owners. Residents of the LRGV, however, have the lowest per capita income (see table 6) in the country and highest unemployment rate. As a result, the owners of most of the small brush tracts are not interested in cooperative agreements when they can sell or lease their property for income necessary to maintain a subsistence living standard. Further, Federal funding is still available on a matching basis to help landowners clear brushlands outside the flood plain, of which over 90 percent has already been cleared and converted to farmland.

FWS refuge and TPWD personnel, stationed in the LRGV, have made a major effort with their limited staff to establish a public awareness of the wildlife values of brushlands and show that they are not harsh, worthless, wastelands. Sample English-Spanish brochures are found in appendix F. Approximately 85 percent of the LRGV population is of Hispanic origin.

In summary, the effectiveness of this no action protection alternative appears to be negligible in assuring the future preservation of wildlife habitat in the LRGV. Efforts other than land acquisition will continue, however, with emphasis in expanding a public education/awareness program geared towards the Hispanic community.

B. Acquisition/Management by Others

This resource protection alternative would place the major burden of the preservation effort on TPWD, park and wildlife departments of the counties involved, and private conservation agencies; such as, the National Audubon Society, World Wildlife Fund, Caesar Kleberg Wildlife Research Institute, and The Nature Conservancy. Habitat preservation by these entities is being considered and is encouraged by FWS. FWS is working closely with TPWD to aid the State in acquisition of brush tracts of value to white-winged dove, with money obtained from the sale of white-winged dove stamps. However, funds for acquisition and management by the counties, State, and private conservation agencies are limited. Should FWS cease preservation activities in the LRGV, some lands would still be preserved by State and local governments

Table 6.-Nation's Richest, Poorest Cities*

"...Census Bureau figures show cities in Texas have both the highest and the lowest average incomes in America. At $16,467 a year, the oil town of Midland boasted the highest per capita income in the nation's 305 standard metropolitan statistical areas in 1981. Three Texas communities on the Mexican border had the lowest. The year's high and low per capita incomes--...."

15 Richest		15 Poorest	
Midland, Tex.	$16,467	McAllen-Pharr-Edinburg, Tex.	$5,606**
Bridgeport-Stamford-Norwalk-Danbury Conn.	$15,697	Laredo, Tex.	$6,148
Anchorage, Alaska	$15,563	Brownsville-Harlingen-San Benito, Tex.	$6,172**
Casper, Wyo.	$14,979	Provo-Orem, Utah	$6,317
San Francisco-Oakland	$14,416	Jacksonville, N.C.	$7,089
Washington, D.C.-Md.-Va.	$14,177	Las Cruces, N.M.	$7,237
Nassau-Suffolk, N.Y.	$13,676	El Paso, Tex.	$7,360
San Jose, Calif.	$13,529	Fayetteville, N.C.	$7,404
West Palm Beach-Boca Raton, Fla.	$13,337	Alexandria, La.	$7,411
Houston	$13,303	Bloomington, Ind.	$7,541
Layfayette, La.	$13,284	Anniston, Ala.	$7,614
Reno, Nev.	$13,255	Florence, S.C.	$7,669
Anaheim-Santa Ana-Garden Grove, Calif.	$13,027	Clarksville-Hopkinsville, Tenn.-Ky.	$7,716
Newark	$13,001	Gainesville, Fla.	$7,737
Seattle-Everett, Wash.	$12,841	Anderson, S.C.	$7,738

*Source: U.S. News and World Report, May 23, 1983.
**Towns located in LRGV.

plus the environmental community; but because of limited funding, the amount of land acquired would be inadequate to perpetuate the unique wildlife habitats of this area. Therefore, what is needed to acquire sufficient habitat is cooperation between the Federal Government, State and local agencies, and private groups--not abandonment of the program by FWS. For more information on the close-working relationship with TPWD on land acquisition, see the draft cooperative agreement in appendix D. For a more detailed listing of the public and private groups involved in brush preservation, see table 7.

The IBWC offers the best opportunity for another Federal agency to participate in brush acquisition or management by others. In 1970, Mexico and the United States signed a treaty to resolve pending boundary differences and maintain the Rio Grande as the international boundary between our two countries. IBWC is the United States agency responsible for restoring the Rio Grande's character as an international boundary and minimizing future changes in the channels of this river. FWS has enjoyed an excellent working relationship with IBWC, and development of a cooperative agreement may prove beneficial in the future in assisting both agencies to carry out their respective programs. IBWC presently has acquired fee title to most of the lower Rio Grande riverbed (center to United States' bank) from the State and maintains structures along the shore to minimize changes in the channels. IBWC plans to acquire easements along the river flood plain to restrict construction and other development. These restrictions, however, will not include provisions to protect brush habitat.

C. Less-Than-Fee Acquisition

Under this alternative protection measure, FWS would assume management responsibility only for wildlife preservation on the proposed project lands or those portions of the area under agreement (lease, easement, deed restriction, management agreement, term/life use, or similar device where fee title remains with the landowner). The purpose of management by FWS would be to preserve wildlife diversity and quality wildlife habitat. The owners of the land would give up certain rights or uses, which would conflict with wildlife management goals. However, the lands would remain on the county tax rolls,

Table 7.-Resource Protection Alternative B
Acquisition/Management by Others in LRGV, Texas

TPWD (both State parks and State wildlife management areas)
National Audubon Society
Sabal Palm Sanctuary
Frontera Audubon Society
Rio Grande Valley Audubon Society
The Nature Conservancy
World Wildlife Fund
Caesar Kleberg Wildlife Research Institute
IBWC
National Park Service
Texas General Land Office
County parks
Municipal parks
Highway Department
Water districts
HUD (Brownsville Project)
School campuses
Native Plant Project
Sierra Club
Lone Star Chapter of Sierra Club
Brownsville Zoo
Methodist Thorn Thicket
Tucker de Shazo Refuge
Port Mansfield Port Authority
Brownsville Navigation District
Boy Scout Camps (Camp Perry)
LRGV Development Council
Water treatment plants
Railroad right-of-way
Winter Texan mobil parks
Citrus orchards
Soil Conservation Service
Golf courses
Individual private-property owners
Palo Alto National Monument (Brownsville)

and the owners would retain all ownership and land management options, except those prohibited by terms of the agreement with FWS. See appendix D for sample agreements.

Use of this alternative has some applicability as a preservation tool for the LRGV NWR; however, its effectiveness and cost efficiency is questionable or limited for many of the small, privately-owned properties in the project.

Leases of property for a specified number of years have been utilized by FWS on a number of refuges. The lease automatically terminates at the end of the agreement period, and the land or brushlands would again be subjected to the threat of destruction. Under provisions of P.L. 91-646, lease payments to owners must be based on just compensation; therefore, costs associated with preparation of appraisal reports and other overhead would be the same as those involved in any other form of acquisition, i.e., fee or easement. However, under Federal procurement regulations, payment for leases may not be made until the service--in this case, wildlife management rights--are actually received by the Government. As a result, landowners do not receive payment until after the period of use, unlike the practices followed in the private sector. This "payment in arrears" has caused FWS numerous problems, especially in cases where the owners received their money late and the terms of the lease were not fully honored. Annual payments are commonly used; however, few landowners are willing to lease property and wait over a year for payment. Making payments three to four times a year creates a fiscal problem since, commonly, the checks are not sent to the owners on time. As a result, landowners often lose confidence with the Government, and poor public relations occur. The lease terms may be violated by the landowners; and the Government has little recourse against the owner, except not making payment. Preservation of the brushlands is not assured under this alternative, especially if the owner lacks confidence in the Government. Use of mutually-beneficial, no-cost leases, especially on brushlands owned by public entities, offers merit as a preservation alternative and is being utilized by FWS in the LRGV NWR. See the proposed 40-year lease with the Brownsville Navigation District in appendix D. Use of leases with an option to later acquire fee title on some large properties also has merit, especially where the owner is interested in selling brushlands but FWS does not have sufficient acquisition money in any one year to acquire the entire property. The lease of wildlife management rights assures preservation of the brushlands until funds are available to acquire fee title. Under present Government procurement regulations, FWS is prohibited from paying landowners more than $1 for an an option to purchase property. Owners are not willing to tie up their entire property for 1 year or longer for only $1, since FWS might not be able to accept the option, or the land values may have increased 5 to 10 percent from the time the option to purchase was orginally obtained. Further, owners are cautious about selling their land in parcels over 2 or more years. There is always the risk FWS may acquire the first parcel but funds will not be available in future budgets to complete the acquisition, thus leaving the owner with a tract that may be difficult to sell on the private market.

Purchase of lands, with owners retaining a life use or term use, offers merit as a preservation alternative for some tracts in the proposed refuge project. However, many of the landowners of small brushland tracts have a very low income and need full payment at the time the land is acquired. There is also the risk that the party reserving the term use will clear brushlands or violate a wildlife management condition. This alternative may be applicable for tracts owned by elderly people living on brushlands that are interested in retaining a life use of the house and a few surrounding acres. Where applicable, this alternative will be offered to landowners; however, few people reside in the flood plain along the river where most of the brushlands are located.

Use of conservation easements is a viable preservation alternative for this project and offers great merit or potential in aiding establishment of a wildlife corridor along the river flood plain connecting fee management units. To reduce overhead costs and assure future preservation of brushland habitat, perpetual easements should be used. The typical easement will grant FWS wildlife management rights on the property with the owner retaining all other uses. FWS will have the right to fence and post the easement area, and prohibit clearing of brushlands and uses that would impact wildlife habitat; such as, overgrazing, excessive public use, etc. See appendix D for sample conservation easement.

A summary of the management/acquisition overhead costs and staff needs for this preservation alternative are shown in the appendix.

D. Fee Acquisition

The proposed fee acquisition of lands in this project would result in the preservation of riparian and adjacent upland habitat and associated wildlife. Soil conservation, brushlands, and water quality in the area would improve after FWS fee acquisition. The purchase of brushland tracts, rounding out and/or connecting the 6,000 acres presently in the Santa Ana refuge complex, would greatly facilitate and enhance FWS management. The extraction of mineral resources from the project lands could continue to take place under FWS administration. Landowners can retain oil and gas rights with any development taking place under restrictions in the deed protecting the wildlife resources. Parcels of agricultural land included in brushland purchases will be gradually converted to woodlands, over a period of years, through cooperative management agreements with former landowners, who will be given an opportunity to continue farming and assist in restoration of wildlife habitat. The local county will receive refuge revenue sharing funds for any lands acquired in fee by FWS in the refuge project.

Property owners selling land in fee will receive relocation assistance; however, very few residences are included in the project proposal, especially the flood plain along the river, and relocation costs should be nominal. Any excess lands acquired will be used for exchange purposes to block out management brush units.

FWS will continue exploration of acquisition by donation; however, most of the small ownerships are held by low-income families and offer little opportunity for gifts.

A summary of the management/acquisition overhead costs and staff needs for this preservation alternative are shown in the appendix.

E. Combinations

The best and most expedient method of preserving the unique habitat and wildlife in the LRGV calls for the use of all practical protection alternatives discussed in this plan. The plan depends on the preservation of brush habitat by private individuals, conservation agencies, and local and State entities, including TPWD and FWS. The key to success of this preservation effort will depend on the ability of FWS to develop a cooperative effort working together with the landowners. The best preservation alternative appears to be a combination fee and easement purchase program to establish a wildlife easement corridor along the river between fee management units and utilization of the same approach connecting the Tres Corrales-La Sal Vieja area. The alternative receiving the best acceptance from the property owners will dictate, to a great extent, the direction FWS will follow. Without public acceptance, working with willing property owners on any plan for the LRGV will be unsuccessful.

IV. SUMMARY OF ALTERNATIVES

The no action alternative typically means a "status quo" situation with few changes anticipated. This uncertainty prohibits FWS from providing the optimum protection to the wildlife habitat located in the LRGV since: (1) no existing or anticipated Federal or State laws, regulations, or local ordinances are present to assure future protection of this habitat; (2) property tax laws offer no incentive or financial advantages to landowners to preserve wildlife habitat; (3) termination of future FWS land acquisition for this refuge would leave the Government with numerous small, isolated brush tracts scattered along the river flood plain, thus severely impacting opportunities for improving or facilitating better management of an important unit of the refuge system; (4) census figures show cities in the LRGV have the lowest per capita income in the county, and landowners cannot afford to preserve brushlands on their own without some form of economic incentive; and (5) under this alternative, most of the remaining critical wildlife habitat identified in this land protection plan wil be destroyed within the next 5 years.

Use of the acquisition/management alternative will be vigorously pursued and encouraged wherever possible, especially with TPWD, IBWC, and the environmental community; but adverse wildlife impacts will continue to occur since: (1) too few brushland tracts will be preserved for wildlife management; (2) sufficient funds are not available in either the public or private sector to acquire and manage this habitat; and (3) IBWC's plans to minimize future changes in the Lower Rio Grande will not include restrictions covering protection of brush habitat.

The less-than-fee acquisition alternative has merit and should be utilized to the maximum extent possible, but adverse wildlife impacts will continue to occur since: (1) some property owners may not accept easements on their land, especially in perpetuity, and for a variety of reasons prefer to sell fee title; (2) Government overhead and purchase costs associated with acquiring easements can be higher than direct fee purchase for certain properties; and (3) landowners may object to easement restrictions, covering wildlife protection measures, reducing livestock grazing or controlling uses such as burning, etc.

The fee acquisition alternative offers the optimum or best way to assure future protection or preservation of brushland habitat, but adverse wildlife impacts will likely occur since: (1) based on past budget levels, it is highly unlikely FWS will receive sufficient acquisition funding in time to preserve the 60,000 acres of presently unprotected habitat under imminent threat; and (2) some landowners will never willingly sell their brushland property to anyone and elect to clear the land for agricultural or other economic purposes.

The combination alternatives discussed in section 4E offers the best opportunity to assure future protection of brushlands in this project. The key will depend on public acceptance and future funding available for preservation and management.

V. SOCIO-CULTURAL IMPACTS

The study area is located in the LRGV and Middle Rio Grande Valley (MRGV) economic study areas of Texas. Three of the counties are in the LRGV economic study area: Cameron, Hidalgo, and Willacy. The remaining county, Starr, is a part of the MRGV economic study area. Major cities within the study area and their 1976 estimated populations are: Brownsville (71,892), McAllen (51,629), Harlingen (40,824), San Benito (17,197), Mission (17,024), Weslaco (19,966), Pharr (19,483), Rio Grande City (5,720), and Raymondville (9,284) (Texas Almanac and State Industrial Guide 1980-1981, The Dallas Morning News). Two Standard Metropolitan Statistical Areas (SMSA's), Brownsville-Harlingen-San Benito and McAllen-Pharr-Edinburg, are established in the study area (see table 6). Individual county economic and demographic summaries follow:

1. Cameron County: 896 square miles in area; estimated 1977 population of 176,500. Income is derived from fruits, vegetables, agribusiness, seafood processing, fishing, shipping, tourism, and manufacturing. Mineral production consists of natural gas and petroleum. Income in 1979 totaled $732,034,000, and total wages paid in 1978 amounted to $433,718,400. Assessed valuation in 1978 was $371,074,090. Per capita income in 1976 was $3,825 while median family income was $7,600 for the same year.

   This county is one of the State leaders in total farm income. Annual farm income is about $85 million. Farm income is derived from cotton, sorghum, fruits, vegetables, sugarcane, livestock, and poultry. Over 200,000 acres are under irrigation.

   Cameron County is a year-round resort area. Recreation is based on fishing, hunting, water sports, and as a gateway into Mexico.

2. Hidalgo County: 1,543 square miles in area; estimated 1977 population of 232,300. Income is derived from food processing, shipping, agribusiness, tourism, mineral production, and agriculture. Mineral production average annual income is $128 million, mainly from oil, gas, sand and gravel, and stone. Income totaled $864,632,000 (1979), and wages paid

were $521,830,652 (1978 estimate). Tax value assessment in 1978 was $513,740,070. Per capita income in 1976 was $3,338 while median family income was $8,000.

The county is a leader in crop production, averaging $190 million annually. Approximately 90 percent of agricultural income comes from crops; principally, cotton, citrus, grain, vegetables, and sugarcane. Livestock production includes cattle, hogs, poultry, and horses. Approximately 270,000 acres of land were irrigated in 1979.

Recreational opportunities include hunting and fishing and serving as a gateway into Mexico. The county is popular as a winter resort and retirement area. The foreign trade zone located south of McAllen encourages trade with Mexico.

3. Starr County: 1,211 square miles in area; estimated 1977 population of 21,700. Income is derived from vegetable packing, shipping, agribusiness, oil processing, and tourism. Income in 1979 was $56,375,000, and wages paid amounted to $21,418,860 (1978 estimate). County tax-assessment valuation in 1978 was $109,196,970. Mineral production annually averages $84.4 million, mainly from oil, gas, and clays. Per capita income in 1971 was $1,622, and median family income in 1971 was $3,695.

   Sorghum, vegetables, and beef cattle produce an average annual agricultural income of $32 million. The county has about 12,000 acres of irrigated land.

   Falcon Reservoir, situated on the Rio Grande in the southwest corner of Starr County, contributes greatly to water-based recreational activities and adds to the local economy. Deer and white-winged dove hunting also contribute to the recreational picture.

4. Willacy County: 591 square miles in area; estimated 1977 population of 16,800. Principal business income is derived from oil, agribusiness, and tourism. Port Mansfield, a gulf coast fishing port and shrimp processing center, contributes substantially to the local economy. Income in 1979

was $56,194,000, and wages paid totaled $21,217,616 (1978 estimate). Tax valuation in 1978 was $85,940,386. Oil and gas production amounts to an average yearly income of $35 million. Per capita income in 1975 was $2,882, and 1977 median family income was estimated at $6,600.

Agricultural income has an average yearly receipt of $50 million, primarily from crops (90 percent of total); such as, cotton, sorghum, sugarcane, vegetables, and citrus. Livestock production centers on cattle and hogs. The county has about 38,000 acres of irrigated land.

Recreational opportunities are supplied by hunting and freshwater and saltwater fishing. The mild climate also attracts many winter residents.

Income

Per capita income in the four-county area has ranked at the bottom of the 266 SMSA's in the United States for many years. The area's per capita income has averaged 50 to 60 percent of the Texas and United States averages. This low income status affects the buying power of the area.

Agriculture

The LRGV is a major agricultural producer within the State. The area livestock and crop receipts totaled $320,685,000 in 1976, and this total accounted for about 5 percent of the State total. Table 8 presents the four-county and State agricultural receipts for 1974.

Employment/Unemployment

The study area has a consistent high rate of unemployment. While the LRGV is a growing area (adding 6,000 to 8,000 persons per year since 1974) employment has not kept pace with the number of people entering the labor force. Major sources of employment are manufacturing; trade; services; and local, State, and Federal Government.

Table 8.-Agricultural Census, 1974, Four-County Study Area*

County	Number Farms	Land in Farms (Acres)	Average Size of Farms (Acres)	Value Crops Sold ($1,000)	Value Livestock and Poultry Sold ($1,000)	Cropland Harvested (Acres)
Cameron	1,515	397,376	262	49,658	8,706	232,691
Hidalgo	3,020	858,041	284	124,024	9,148	406,022
Starr	856	488,984	571	8,329	4,627	32,312
Willacy	442	313,186	709	31,295	793	170,547

*Texas Almanac and State Industrial Guide 1978-79, The Dallas Morning News.

Recreation

Recreation in the area is directly related to facilities available. Freshwater and saltwater fishing and hunting are the major consumptive recreational activities. White-winged dove hunting adds substantially to the LRGV economy. Water-related recreation on Falcon Lake also adds materially to recreation values. Other recreational activities in the LRGV are tourism and access to Mexico.

Transportation

Two major highways, 281 and 77, lead north from the LRGV area. Highway 83 runs from the east to the west and provides transportation along the LRGV. Rail transportation into the area is provided by the Missouri Pacific and Southern Pacific Railroads, but is limited primarily to Hidalgo and Cameron Counties. Principal means of crop and other product movement is by the trucking industry.

Air transportation facilities are available at three major airports in Brownsville, McAllen, and Harlingen; seaports are located at four different coastal locations.

Impact on Socioeconomic Resources

There are no known commercial or industrial plans for any of the tracts considered for preservation. Mineral and/or energy exploration would be allowed if consistent with applicable laws.

An adverse impact upon the four-county area would be the cessation of converting brushland, acquired by FWS, to agricultural production. Such impact would be negligible in view of the total number of acres involved as compared to total acreage in the four-county area. Acquisition of the 100,000 acres would constitute less than 3 percent of the total acreage in the four-county area.

Acquisition of the tracts under an easement will cause little change in land ownership or usage. In acquiring the land on a fee title basis, the land would be removed from local tax rolls. To compensate the county for such removal, an annual payment is made to the county in lieu of taxes under the provisions of the Refuge Revenue Sharing Act (16 U.S.C. 715s; 49 Stat. 383, as amended). This annual payment usually exceeds current tax payments. Land acquired through easement does not qualify for revenue sharing funds because the land remains on the tax rolls.

Preservation of the wildlife habitat will continue to add to recreational opportunities in the area. White-winged dove hunting will be enhanced because preservation of the brushlands will provide vital nesting and roosting areas which are essential to the continued existence of these birds. The brushland will also provide cover for vertebrate wildlife in the area.

Larger tracts of land would be considered for public uses; such as, birdwatching, hunting, and nature study. Any such public uses would be in accordance with FWS management practices to ensure perpetuation of high quality wildlife habitat.

Those landowners who provide hunting leases on lands adjacent to or near the acquired tracts would benefit from the continued supply of birds for hunting purposes. This economic benefit would continue.

VI. COORDINATION

A. Local

The FWS habitat preservation program in the LRGV has been ongoing since 1974 and, as such, has been given widespread publicity with local landowners, the community in general, and business and civic groups located in and around the area of concern. All FWS activities, regarding preservation of wildlife habitat in the LRGV, have been closely coordinated with TPWD staff. Much of the biological data for the white-winged dove and other wildlife habitat needs in the LRGV was prepared by local TPWD personnel. Public groups, Government agencies, and individuals contacted regarding this and previous land protection plans and proposals for the LRGV, are listed in table 9.

Approximately 500 landowners throughout the LRGV area have been contacted since early 1974, and the FWS habitat preservation program explained through the combined efforts of professional staff personnel from FWS divisions of Realty and Refuges. There has also been considerable landowner contact through TPWD personnel and interested members of the conservation community in the LRGV.

The value of the Tamaulipan communities and the awareness of their vanishing status is reflected in the overwhelming acceptance of the program from the local community, conservationists, and landowners alike. Following is a summary of comments and concerns of the public and landowners regarding this project:

1. If landowners are willing to enter into any form of agreement with FWS concerning preservation of their brushlands (fee purchase, easement, lease, or other form of instrument), it's up to the individual owner to decide. If the owner is satisfied, the public will not object. In Texas, pride of ownership is considered a private matter. The owner should have the right or freedom of choice concerning use or disposal of all real property. Use of condemnation by the Federal Government to acquire

any interest in brushland, including an easement or lease, would receive strong opposition, however, from the public.

2. The public would strongly oppose any effort to zone private-rural land for any purpose in Texas. Landowners should have the right to clear brushlands; dedicate them for park, refuge, or other recreational purposes; or use their land as they see fit.

3. The public favors retention of oil and gas rights by the private sector, but would accept reasonable restrictions or controls on any mineral development in the LRGV--especially along the flood plain--that would assure future protection of wildlife habitat.

4. The public recognizes the significant income that is received or pumped into the local community each year from hunting in the LRGV. During white-winged dove season, a motel room is nearly impossible to obtain.

5. Some landowners are skeptical about nondevelopment easements to protect their brushlands. They clearly understand potential economic uses of their property and would consider the benefits and/or costs associated with making a decision to either clear brushland or sell them for wildlife purposes. The retention of fee title, however, with a restriction of clearing their land forever has some landowners concerned about the prospect of losing some unknown source of potential income from their property in the future. Conservation easements are a new concept to landowners in Texas, and it will take considerable public education to convince them of the advantages of retaining fee title to lands.

B. State

The State-Federal relationship developed in the habitat preservation program for the LRGV since 1974 is a distinctive example of the Secretary of the Interior's new policy addressing State and Federal relationships in managing fish and wildlife resources.

FWS has conducted all landowner contacts, appraisals, ascertainment, and other related habitat preservation efforts with the full knowledge and approval of TPWD. TPWD, the Texas Conservation Foundation (TCF), and the Texas General Land Office (TGLO) are the Governor's official representatives for fish and wildlife activities within the State of Texas. TFC was created in 1969 by the State legislature to act as trustee for gifts of land, money, or other valuables donated to the State. These gifts are used, in accordance with the wishes of the donors, for the benefit of the Texas system of parks, historical sites, wildlife, and natural areas. TPWD personnel commonly accompany FWS Realty and Refuge employees during initial contacts with landowners to discuss preservation alternatives for brushlands in this project. FWS also presently has a draft memorandum of agreement under review for FWS and TPWD to cooperate in planning, carrying out, and operating a program to acquire and manage lands for wildlife in the State of Texas for the express purpose of maintaining and increasing migratory bird and other wildlife populations (see appendix D). TPWD and FWS jointly published a Spanish-English brochure on the wildlife values of the Rio Grande corridor (see appendix F).

As with the summary of comments in the local community, the program has considerable support from the State level. The Governor of the State of Texas has supported FWS land acquisition, provided all land purchases meet the following criteria: (1) acquired by negotiated purchase only from willing sellers at fair market value; (2) FWS makes payment in lieu of taxes, so that the county in which land is located will not suffer unduly from a loss of tax base; (3) assure that proper provisions for hunting, fishing, and other recreational uses by the public will be permitted in this area consistent with sound wildlife management principles and practices; and (4) afford TPWD the option and opportunity to participate and cooperate in the management of any lands acquired by FWS under this program.

Table 9.-Government Agencies, Public Groups, and Individuals Contacted Regarding Land Protection

Valley Chamber of Commerce	Russell Willis, Executive Director, Weslaco
Texas A & M University	Doug Slack and Fred Hendricks, Biologists, Wildlife and Fisheries Sciences Department Robert Whitson, Economist Robert Baker, Forestry, Remote Sensing William Merrill, Research Associate, Range Science
Texas Agricultural Experiment Station	Chan Connolly, Director, Weslaco Experiment Station
Texas Agricultural Extension Service	Tony Mazzaccaro, Area Recreation and Parks Specialist, Corpus Christi Charles Ramsey, Wildlife Specialist, College Station
Hidalgo and Cameron County Water Control District No. 9	W. D. Parsh, Executive Director, Mercedes
Lower Rio Grande Valley Development Council	Ralph Boeker, 208 Planner, McAllen John Janak, Resources Planner, McAllen Clancy Nolan, Director, Economic Development
Brownsville Navigation District	Ersel Lantz, Port Brownsville
Texas Water Rights Commission	Frances Baughn, Director, Weslaco
Agricultural Stabilization and Conservation Service	Richard Whittington, Director, Hidalgo County Alfonso Perez, Starr County Calistro Noya, Willacy County, Raymondville
Soil Conservation Service	Jack Elrod, Edinburg Norman Bade, Mission Barney Lee, San Benito Sylvester Garcia, Rio Grande City August Turner, Raymondville
U.S. Department of Agriculture	James Everett, Alvin Gerbermann, and Craig Wigdon, Remote Sensing, Weslaco
International Boundary and Water Commission	Lupe Nerio, Harlingen, and Monty Bell, El Paso
Caesar Kleberg Wildlife Research Institute	V. W. Lehmann, Biologist, Kingsville

Table 9.-Continued

King Ranch	William Kiel, Biologist, Kingsville
National Audubon Society	Russel Peterson, President, New York City David Blankenship, Biologist, Rockport Dede Armentrout, Southwestern Regional Representative, Brownwood Neil Murray, Chairman of Local Conservation Committee, McAllen Amos Eno, Washington, D.C.
Pan American University	Pauline James and Frank Judd, Biologists, Edinburg Carl H. Rush, Jr., Director, Bureau of Business and Economic Research, Edinburg
Texas Archeological Research Laboratory	Carolyn Spock, Research Associate, Austin
Texas Parks and Wildlife Department	Ted Clark, Director, Austin Gary Waggerman, Biologist, Edinburg
Texas General Land Office	Mike Hightower, Director, Coastal Div. Richard Goodman, Land Acquisition
Texas Real Estate Research Center	Arthur Wright, Research Economist, College Station
Hidalgo and Willacy County Water Control & Improvement Dist. #1	Mike Brenner, District Water Manager, Edcouch
Hidalgo County Tax Assessor Collector's Office	Elsa Alonzo, Edinburgh
Willacy County Tax Assessor Collector's Office	Emma Ross, Raymondville
U.S. Army Corps of Engineers	Chester Martin, Biologist, Environmental Resources Branch, Galveston Joseph Trahan, Chief, Engineering Division, Galveston Frank G. Incapera, Engineering Division, Galveston Alejandro Garcia, Area Engineer, Brownsville
Texas Conservation Foundation	Dr. John Hamilton, Executive Director
Landowners	Approximately 500 property owners have been contacted regarding LRGV preservation project since 1978


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VII. FINDINGS AND RECOMMENDATIONS

A. Existing Protection

The existing protect.on for Santa Ana and .RGV refuge complex are as follows:

Resource Protection Alternative	Estimated Acreage Now Protected	Remarks
A. No Action	24,000	Consists of brushlands largely in Falcon woodlands area, where quiet title actions have not been completed. Once title problems are cleared, habitat will be under eminent threat of destruction. In spite of the present uncertainty of ownership, some brush clearing is presently underway.
B. Acquisition/Mgmt. by Others	10,000	Wildlife habitat protected by TPWD, county and c.ty parks, IBWC and private environmental organizations, citizen groups and individual landowners. Includes 4,600 acres to be lea.ed at no cost from the city of Br.wnsville for 40 years. Most wildlife habitat appears relatively safe at this time.
C. Less-Than-Fee Acquisition	500	Managed by lease (no cost) by FWS under agreements with IBWC and Hidalgo Water District. Protected as long as leases are in effect.
D. Fee Acquisition	5,500	Acquired by FWS from 1942 through 1983 by fee. Purchase using MBCA and LWCF money. Protected.
E. Combinations	40,000	Total currently protected. Combination of alternatives A-D.
Total Protection Goal/ Objective for Refuge*	(100,000)*	See "Project Objective," section 2C, of land protection plan.
Deficit - Needs Protection	-60,000	Wildlife habitat communities identified in land protection plan privately owned where landowners have not yet cleared brushlands or drained wetlands. Presently under high potential threat of destruction.

B. Priorities for Protection

Preservation strategy calls for immediate attention to the 60,000 acres of unprotected wildlife habitat, owned by the private sector, that has not yet been destroyed by clearing of brush or drainage of wetlands/potholes. The 10 wildlife community areas identified are of equal biological importance; however, as individual cover-type goals are reached or a high percentage is under some form of protection (alternatives A-D), emphasis will be switched to areas in the highest remaining unprotected deficit status. First priority will be given to habitat in the flood plain along the river in order to improve and facilitate management of the existing scattered brush tracts in refuge status. This should be accomplished by rounding out 15 or more fee management units (2,000 to 4,000 acres in size) connected by a miminum 100-meter-wide nondevelopment easement along the shoreline of the river. The 100-meter easement may be expanded in portions of the river where the flood plain is wider or feeder streams/arroyos enter the Rio Grande.

Second priority will emphasize protection of the Tres Corrales-La Sal Vieja portion of the refuge through use of a combination of fee-easement alternatives for brushlands and potholes. Brushland preservation will take priority over potholes in this area; however, the acres or percentage of unprotected habitat in each of the 10 biological communities will be used as the monitoring device for placing emphasis or preservation effort on individual ownerships.

When title curative actions are completed by the courts for any of the 24,000 acres currently listed under the no action alternative, these tracts will be added to the 60,000-acre, first-priority, deficit-protection alternative. The brushlands in the Falcon woodlands area are very important (ranked No. 5 nationally by FWS for protection in 1978) and should receive immediate attention when landowners have been identified. Since title companies will not provide insurance on these lands, private attorneys are presently working on the court quiet title actions. Since most of the apparent owners cannot afford attorney fees, the lawyers will receive a one-third title interest in the property they perfect title on for their clients.

C. Methods of Protection

There appears to be no one, single, preferred method of protection for the 100,000 acres of critical wildlife community habitat identified in this land protection plan. To be successful, a combination of all feasible approaches must be vigorously pursued. The apparent safest permanent or perpetual preservation alternative calls for direct fee or easement purchase by FWS, the Wildlife Division of TPWD, or private conservation organizations dedicated to the protection of this critical wildlife habitat. There appears to be more need for land protection than the total resources available to accomplish the goals cited for the LRGV NWR. The key to success will depend on the landowners. Without their cooperation the protection objectives cannot be accomplished.

D. Excess Lands

Because of the large number of small brushlands included in this proposed project, few excess lands, if any, should be acquired by FWS. Any excess croplands acquired along with adjacent brushlands will be used for exchange to block in management units. Some fields surrounded or joined by brush will be restored to wildlife habitat by working with former owners or tenants under cooperative farming agreements. If FWS is unable to protect the 100,000 acres of wildlife habitat identified in this plan, consideration should be given in the future to reforestation of cleared lands, especially along the river in the Rio Grande flood plain. A large scale brushland restoration program would be a very expensive preservation alternative, but may be necessary in the future if the proposed land protection efforts are unsuccessful.

E. Proposed Action

The recommended plan of action for the LRGV NWR land protection plan, resource protection alternative E, "Combinations," include the following strategies:

Resource Protection Alternative	Proposed Action
a. No Action (Land Acquisition)	Update joint FWS-TPWD Spanish-English brochure and develop short 10-12 minute slide-tape program to educate the public about the need to protect wildlife resources on private land. Increase wildlife technical assistance to landowners throughout the LRGV.
b. Acquisition/Mgmt. by Others	Continue close cooperative joint preservation effort with TPWD. Increase Realty technical assistance to State to encourage accelerated purchase by TPWD through Federal aid and other programs. Develop cooperative agreement and implement joint plan with IBWC covering purchase of restrictive development easements along river corridor that will complement both Federal agencies' program needs (if possible utilize a single U.S. easement document that may be used by both agencies). Encourage environmental organizations to accelerate protection of private lands, through donations, deed restrictions, or purchase of additional brushlands. Encourage passage of law in Texas authorizing conservation easements. Accelerate work with local public agencies in developing agreements, licenses, leases, and other cooperative arrangements to protect wildlife habitat on their lands.
c. Less-Than-Fee Acquisition	Initiate major effort to acquire conservation easement with minimum management rights needed to establish wildlife corridor along river (at least 100 meters back from Rio Grande) and connect existing FWS, State, and private preserves.
d. Fee Acquisition	Accelerate effort to round out or complete purchase of fee management units from current list of willing sellers along river and in Tres Corrales-La Sal Vieja area. Strengthen future budget submittals to Central Office as appropriate to clarify need for stable increased funding source during next 5-year critical period.

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Assessment and Use of Water Rights

by

Lower Rio Grande Valley National Wildlife Refuge

(July 1995)

The Lower Rio Grande Valley National Wildlife Refuge (LRGVNWR) was established in 1980 to preserve the biodiversity in the Lower Rio Grande Valley, Texas. Since its inception, the refuge has been acquiring land mostly with federal monies budgeted through the Land and Water Conservation Fund. As of 1995, the LRGVNWR has purchased approximately 64,000 acres and proposes to acquire a total of 132,500 acres for protecting the fauna and flora of the Lower Rio Grande Valley.

In the process of acquiring land, LRGVNWR has also acquired water rights associated with the properties whenever possible. Use of water rights include irrigation of agricultural crops by cooperative farmers, irrigation of native seeds and seedlings used in the refuge's revegetation program, and water management of wetlands.

Presently, LRGVNWR has 16,640 acre feet of water rights. Most of water rights were acquired individually but are now under combined adjudication numbers A126-001 (720.8 acre ft.) and B126-001 (10,319 acre ft.) (Appendix A). Some of the water rights are still listed by the tract of land they were acquired under; however, these will be combined in the future. The combination of water rights allows use of these individual water rights on any tract of land owned by the U.S. Fish and Wildlife Service in Lower Rio Grande Valley. This allows the refuge more flexibility in meeting water needs by area on refuge land.

The question has been raised as to whether 16,640 acre feet of water rights is enough to meet the present and future water needs of the refuge. In order to assess the refuge's water needs, a summary of water use by cooperative farmers, the revegetation program, and potential wetland restoration projects was calculated.

Many of the tracts of land that LRGVNWR acquires are agricultural fields. Agricultural fields that are acquired often are farmed by cooperative farmers until the fields can be revegetated with native plants. These fields are gradually phased out of agriculture. The length of time depends on the success of revegetation efforts, the availability of seeds and seedling, and other management needs that can be accomplished through the cooperative farm program (fencing, wetland restoration, etc.). The cooperative farm program uses approximately 3,812 acre feet of water annually (Appendix B). The revegetation program uses approxmately 250 acre feet of water annually (Appendix B). The water use for both of these programs was calculated from the water rights records kept at the refuge. Also, irrigation needs for crop types were obtained from Natural Resource Service (pers. comm. Alan Moore, Appendix C) and used to estimate water requirements for the cooperative farm program. A summary of LRGVNWR tracts with active cooperative farm plans that use irrigation water are listed on Appendix B. Even if no other land is acquired for the refuge, the revegetation and the cooperative farming program would continue for another 5 (minimum) to 10 years maximum.

Eventually though, water use by the cooperative farm program will be eliminated because all of the agriculture fields will be revegetated with native vegetation. Most of the fields that are revegetated will only required water for the initial irrigation to germinate seeds and water newly planted seedlings. However, some of these fields could be managed as flood forest and would require water on an annual schedule. Presently, it is estimated that approximately 1.1% (711 acres) of the land acquired thus far could be managed as flood forest (Appendix D) and would require approximately 1,422 acre ft. of water (2 acre ft of water per acre of flood forest; based on flood forest management by Rio Grande - Bentsen State Park). If land acquisition program attains the goal of 132,000 acres, and assuming that 1.1 % of the land can be managed as flood forest, then 1,452 acres of flood forest would require 2,904 acre feet of water.

Water management on LRGVNWR wetlands is at its infancy because of the numerous restoration projects that need to be conducted. In an attempt to accurately assess the potential water use on LRGVNWR wetlands, National Wetland Inventory maps were used to identify wetlands on LRGVNWR tracts. These wetlands were digitized and acres were calculated using ARC/INFO software (Appendix E). It is estimated that the total wetland acres for LRGVNWR are 5,488.4 acres (Appendix D). On LRGVNWR, 1,135 acres of wetlands are actively managed and an additional 1,474 acres of wetlands need to be restored. The remaining 2,879 acres of wetlands cannot be actively managed using river water rights due to their location. A list of some wetland restoration projects and cost associated with is in Appendix F. Materials and costs associated with wetland restoration projects are listed in Appendix G.

It is estimated that it would take 10 acre ft. of water to manage permanent wetlands and 5 acre ft. to manage seasonal wetlands. Using these estimates, it would take 18,755 acre ft of water to manage Santa Ana National Wildlife Refuge and LRGVNWR wetlands. This estimate alone exceeds the 16,640 acre ft of water rights held by LRGVNWR.

In addition, there has been requests to use LRGVNWR's water rights for other wetland and flood forest management projects in the Valley. Laguna Atascosa National Wildlife Refuge is now included as a place of use for LRGVNWR's water rights. They estimated that they could use between 5,000 to 30,000 acre feet of water to manage their wetlands depending on annual rainfall amounts for that year. Rio Grande - Bentsen State Park could use at least 500 acre feet of water to manage flood forests. Sabal Palm Sanctuary can use 300 acre feet of water annually to manage a resaca that is shared with LRGVNWR. Presently, LRGVNWR has a Private Lands Agreement with Mr. Newt Dyer that allows him to use 100 acre ft of LRGVNWR's water rights annually. There is the potential to arrange additional private land agreements of a similar type.

Presently, LRGVNWR does not utilize all of its water rights. However, if all the management programs were active to their fullest potential then the need for water by the refuge would exceed the present amount of water rights held by LRGVNWR. This does not even include the request for water by Laguna Atascosa NWR, Rio Grande - Bentsen State Park, Sabal Palm Sanctuary, and Private Land Agreements.

It is apparent that in the future, the demand for water at LRGVNWR and other refuges in the Valley will exceed the existing allotment presently held by LRGVNWR. Therefore, as LRGVNWR continues to buy land for the refuge, they should also continue to buy river water rights whenever possible. Water is a critical component that is essential to maintaining the biodiversity in the Lower Rio Grande Valley. Without wetland management, it is estimated that the refuge would have 30 to 50% less biodiversity, and consequently wetlands could be classified as critical habitat for many of the wildlife species in the Valley. In addition, water will be essential for restoring and maintaining flood forest habitat that is definitely one of the most unique habitat types in the Valley. Without the potential to manage wetlands and flood forests, LRGVNWR would fail to preserve many species of fauna and flora in the Valley. Undoubtedly, the failure to protect biodiversity would be an immense deficiency to LRGVNWR and the ecosystem.

Water rights will become even more critical as the Lower Rio Grande Valley continues to develop and the demand for water increases. The only opportunity LRGVNWR has in obtaining additional water rights is when it purchases land that has water rights associated with them. If the refuge decides not to buy water rights when available with land purchases, it will never be able to obtain these water rights in the future. Therefore, it is critical to realize the importance of water rights to the refuge and obtain them whenever possible with land purchases. The additional cost of water rights with the land should be viewed as the cost of obtaining quality wildlife habitat; without it, the land is worth only a fraction of the potential with the water rights. Also, obtaining water rights could be looked upon as an investment that will increase in value for the refuge in the future. Its an investment that, if bypassed now, could have severe repercussion in the future. Many examples of this short sightedness can be found on wildlife refuges without water rights in the Western United States. Obtaining water rights allows the refuge to control its own management destiny, but without water, it will be a refuge of regret and a mere skeleton of its potential.

*** The only exception when water rights should not be purchased is when they are associated with an Irrigation District that has annual maintenance assessment fees. These fees impose a severe demand on the refuge's budget and should be avoided in the future.

APPENDIX A

Texas Natural Resource Conservation Commission
Rio Grande Watermaster
Monthly Report Statement for LRGV
4/29/95

Adjud Cert	Tract	Authorized Water Use	Usable Balance
A126-001	Combined	720.865	390.636
B126-001	Combined	10,319.128	7,262.510
0369-000	Abrams	48.900	000.000
0518-001	Abrams West	24.100	11.613
0024-002	La Gloria	355.000	89.616
0528-001	La Joya	772.500	161.296
0600-000	Los Velas	375.000	367.085
0735-000	Los Velas	500.000	237.299
0836-004	La Joya	495.000	471.041
0086-000	Villa Nueva	132.500	32.500
0693-001	Villarreals Banco	17.990	17.990
0169-000	Vaquerita Banco	125.000	120.016
0222-001	Capote Banco	219.575	000.000
0042-001	Champion Bend	80.325	000.000
0045-000	Champion Bend	9.000	000.000
0311-001	Cottam	157.500	000.000
0229-000	Jeronimo Banco	125.000	000.000
0230-000	Jeronimo Banco	408.650	000.000
0648-001	Guerra	6.835	000.000
0679-000	La Coma	1,194.225	000.000
0200-000	Las Sierritas	25.800	000.000
0147-000	Las Sierritas	12.900	000.000
0437-000	Rosario Banco	2.277	000.000
0041-000	Tulosa Ranch	150.000	000.000
0095-000	Tulosa Ranch	275.000	000.000
0144-001	Tulosa Ranch	31.104	000.000
0156-000	Tulosa Ranch	51.500	000.000
0448-003	Vela Woods	4.422	000.000
	Total:	16,640.096	9,161.602

APPENDIX B

Crops Farmed and Projected Irrigation Need For 1995 Cooperatve Farm Agreements

Tract	Acres Corn	Acres Sorghum	Acres Okra	Acres Sugar Cane	Acres Native Seedlings	Acres Native Seeds	Total Acres of Crops	Total Irrigation Water Needed in Acre Feet
Abrams West	230.00	0.00	0.00	0.00	25.00	25.00	280.00	345.00
Capote Banco	0.00	59.50	0.00	0.00	1.20	11.00	71.70	71.70
Garza-Cavazos	0.00	130.20	0.00	0.00	18.00	2.00	150.20	150.20
La Coma Brush	0.00	290.30	0.00	99.60	3.70	33.10	426.70	658.77
La Gloria	0.00	0.00	0.00	0.00	2.00	18.00	20.00	20.00
La Joya	0.00	1033.00	0.00	0.00	50.00	50.00	1133.00	1083.00
La Sierritas Banco	0.00	14.60	0.00	0.00	1.60	13.00	29.20	29.20
Los Velas	0.00	290.00	0.00	0.00	0.00	0.00	290.00	290.00
Marinoff	0.00	87.00	0.00	0.00	0.00	0.00	87.00	87.00
Palo Blanco	0.00	19.90	0.00	0.00	2.00	17.90	39.80	39.80
Pate Bend	0.00	0.00	0.00	0.00	20.00	154.40	174.50	174.50
Phillips Banco	0.00	207.40	0.00	0.00	0.60	5.40	213.40	213.40
Resaca de los Fresnos	0.00	190.60	0.00	0.00	0.00	0.00	190.60	190.60
Resaca Del Rancho Viejo	0.00	477.00	0.00	0.00	0.00	0.00	477.00	477.00
Tahuachal Banco	0.00	59.80	35.00	0.00	0.00	0.00	94.80	164.80
Vaqueteria Banco	0.00	0.00	40.00	0.00	1.00	9.00	50.00	90.00
Villa Nueva	0.00	124.00	0.00	0.00	0.00	0.00	124.00	124.00
Total	230.00	2,982.90	75.00	99.60	125.10	338.80	3,851.10	4,208.97

APPENDIX C

Water Needs for Grain Sorghum and Corn

from the

Natural Resource Service

Contact Person : Alan Moore

Irrigation Needs During Average Years

Grain Sorghum........................1.00 acre feet per acre

Corn.................................1.25 - 1.50 acre feet per acre

Sugar Cane...........................3.33 acre feet per acre

Okra.................................2.00 acre feet per acre

Total Water Need (Including Rainfall and Irrigation)

Grain Sorghum........................1.50 - 1.67 acre feet per acre

Corn.................................2.00 acre feet per acre

Sugar Cane...........................5.33 acre feet per acre

Okra.................................2.00 acre feet per acre

APPENDIX D

Page No.
[illegible]

TRACT	Total Wetland Acres	Active Permanent Wetland Acres	Restorable Permanent Wetland Acres	Active Seasonal Wetland Acres	Restorable Seasonal Wetland Acres	Active Flood Forest Acres	Restorable Flood Forest Acres	Restoration Cost	Water Needed Per Year In Acre Feet	Comments
Abrams	4.00	0.00	2.00	0.00	0.00	0.00	2.00	$ 344.00	30.00	
Abrams West	4.00	0.00	4.00	0.00	0.00	0.00	0.00	$ 344.00	40.00	
Alto Bonito	6.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Boscaje de la Palma	3.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 5000.00	30.00	
Brazos Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Brownsville Brush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Caballero Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	Not owned by refuge
Caja Pinta Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Capote Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Castillo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Champion Bend	3.00	3.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	30.00	Currently not being charged for water
Chapeño	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Chihuahua Banco	32.00	0.00	0.00	0.00	0.00	0.00	32.00	$ 2752.00	160.00	
Clark Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Cottam	70.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	700.00	No control over resaca
Coyote Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Cuellar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Cuevitas	50.00	0.00	8.00	0.00	0.00	0.00	42.00	$ 4300.00	290.00	
Culebron Banco	6.00	0.00	6.00	0.00	0.00	0.00	0.00	$ 516.00	60.00	
East Lake	661.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
El Jardin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
El Morillo Banco	57.00	0.00	44.00	0.00	0.00	0.00	13.00	$ 4902.00	505.00	
Farias	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Fronton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Gabrielson	240.00	0.00	0.00	0.00	0.00	0.00	240.00	$ 20640.00	1200.00	
Garza-Cavazos	8.00	0.00	0.00	0.00	0.00	0.00	8.00	$ 688.00	40.00	
Goodfields	1.00	1.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	10.00	

TRACT	Total Wetland Acres	Active Permanent Wetland Acres	Restorable Permanent Wetland Acres	Active Seasonal Wetland Acres	Restorable Seasonal Wetland Acres	Active Flood Forest Acres	Restorable Flood Forest Acres	Restoration Cost	Water Needed Per Year In Acre Feet	Comments
Granjeno	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Guerra	10.00	0.00	0.00	0.00	0.00	0.00	10.00	$ 860.00	5.00	
Guerra-North	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Havana	7.00	0.00	0.00	0.00	0.00	0.00	7.00	$ 602.00	35.00	
Hidalgo Bend	28.00	0.00	12.00	0.00	0.00	0.00	16.00	$ 2408.00	200.00	
Jeronimo Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Kepler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
La Coma Brush	8.00	0.00	8.00	0.00	0.00	0.00	0.00	$ 688.00	80.00	
La Gloria	71.00	59.00	0.00	0.00	0.00	0.00	12.00	$ 1032.00	650.00	
La Joya	56.00	14.00	0.00	0.00	0.00	29.00	13.00	$ 1118.00	350.00	
La Parida Banco	79.00	12.00	20.00	0.00	0.00	0.00	47.00	$ 5762.00	555.00	No control of resaca
La Pesquera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
La Puerta	23.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
La Selva Verde	592.00	0.00	260.00	0.00	332.00	0.00	0.00	$ 22360.00	2600.00	Seasonal wetland to be w on rainwater only
Lantana	15.00	15.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	Managed by irrigation district
Las Palomas Banco	14.00	0.00	14.00	0.00	0.00	0.00	0.00	$ 1204.00	140.00	
Las Ruinas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Las Sierritas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Las Vegas	7.00	7.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	Managed by irrigation district
Llano Grande Banco	3.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Loma Preserve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Loma Verde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Los Arbolitos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Los Ebanos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Los Olmos	15.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Los Velas	20.00	0.00	20.00	0.00	0.00	0.00	0.00	$ 1720.00	200.00	
Los Velas West	3.00	0.00	3.00	0.00	0.00	0.00	0.00	$ 258.00	30.00	
Lozano	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Madero	47.00	27.00	0.00	0.00	0.00	0.00	20.00	$ 1720.00	370.00	Not being charged for 370 acre ft of this water
Marinoff	25.00	0.00	0.00	0.00	0.00	0.00	25.00	$ 2150.00	125.00	

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06/16/95

TRACT	Total Wetland Acres	Active Permanent Wetland Acres	Restorable Permanent Wetland Acres	Active Seasonal Wetland Acres	Restorable Seasonal Wetland Acres	Active Flood Forest Acres	Restorable Flood Forest Acres	Restoration Cost	Water Needed Per Year In Acre Feet	Comments
Mercedes	15.00	8.00	7.00	0.00	0.00	0.00	0.00	$ 602.00	70.00	No control of resaca
Milagro	32.00	0.00	11.00	0.00	0.00	0.00	21.00	$ 2752.00	215.00	
Monterrey Banco	8.00	2.00	0.00	1.00	0.00	5.00	0.00	$ 0.00	50.00	
Noriega	0.00	86.00	0.00	86.00	0.00	0.00	0.00	$ 1204.00	140.00	
Ocha Holland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Palmito Hill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Palmview	2.00	0.00	2.00	0.00	0.00	0.00	0.00	$ 172.00	20.00	
Palo Blanco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Pate Bend	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Payne	168.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Pharr Settling Basin	367.00	367.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	Not managed by refuge
Phillips Banco	20.00	0.00	8.00	0.00	2.00	0.00	10.00	$ 1720.00	140.00	
Ranchito	295.00	154.00	65.00	0.00	76.00	0.00	0.00	$ 12126.00	380.00	
Rangerville	6.00	0.00	0.00	0.00	6.00	0.00	0.00	$ 516.00	30.00	
Relampago	3.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of controlling resaca
Resaca de los Fresnos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Resaca del Rancho Viejo	242.00	152.00	90.00	0.00	0.00	0.00	0.00	$ 7740.00	2420.00	Not including Adams Gardens Reservoir
Retama	5.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No probable way of accessing river
Rio San Juan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Rosario Banco	25.00	0.00	25.00	0.00	0.00	0.00	0.00	$ 2150.00	250.00	
Sal del Rey	957.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Sam Fordyce North	8.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Sam Fordyce South	28.00	0.00	28.00	0.00	0.00	0.00	0.00	$ 2408.00	280.00	
San Benito Settling Bas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
San Perlita	66.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Sanchez O'Brien	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential.
Santa Ana N-R	120.00	54.00	4.00	0.00	0.00	0.00	62.00	$ 5676.00	1485.00	
Santa Maria	35.00	0.00	8.00	0.00	0.00	0.00	27.00	$ 3010.00	350.00	
Schaleben	70.00	70.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river

TRACT	Total Wetland Acres	Active Permanent Wetland Acres	Restorable Permanent Wetland Acres	Active Seasonal Wetland Acres	Restorable Seasonal Wetland Acres	Active Flood Forest Acres	Restorable Flood Forest Acres	Restoration Cost	Water Needed Per Year In Acre Feet	Comments
Tanuachal Banco	20.00	0.00	20.00	0.00	0.00	0.00	0.00	$ 1720.00	200.00	
Thompson Road Brush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Ticcano Lake	365.00	0.00	365.00	0.00	0.00	0.00	0.00	$ 31390.00	3650.00	
Totuga Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Tulosa Ranch	10.00	0.00	10.00	0.00	0.00	0.00	0.00	$ 860.00	100.00	
Valadeces Banco	8.00	0.00	8.00	0.00	0.00	0.00	0.00	$ 688.00	80.00	
Vacuetería Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Vela Woods	57.00	0.00	3.00	0.00	0.00	0.00	54.00	$ 4902.00	300.00	
Villa Nueve	17.00	14.00	0.00	0.00	3.00	0.00	0.00	$ 258.00	15.00	Permanent wetland managed by irrigation district
Villarreales Banco	16.00	0.00	0.00	0.00	0.00	0.00	16.00	$ 1376.00	160.00	
Villitas Banco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Vista del Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Willamar	325.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Yturria Brush	27.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No way of accessing river
Zamorano	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
Zamora Bend	1.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 86.00	5.00	
Zarate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$ 0.00	0.00	No known wetland potential
TOTAL	5,488.40	1048.00	1055.00	67.00	479.00	34.00	577.00	$162,724.00	18,775.00	

APPENDIX E

(REFER TO BINDER IN WETLAND FILE # 105.111150)

APPENDIX F

Estimated Costs for LRGV Wetland Restoration Projects

The information given in this document is taken from the projected costs for these wetlanc restoration projects as made by Steve Donovan in August of 1994.

	Tract	Wetlands #	Total acreage	Infrastructure Work	Total Cost	Cost Per Acr
5	Ranchito Cameron Cty	8	170	Water Control Structure system, and water delivery system	$13,000	$76.47
6	La Selva Verde Cameron	6	397	Water Control Structure system, ditch plugs, delivery system, pump site	$25,000	$62.97
8	La Gloria Cameron	1	20	Dike Installation, Water Control Structures	$3,500	$175.00
3	El Morillo Banco	1	50	Restore Water Delivery System, and Water Control Structure	$5,000	$100.0C
10	Tahuachal Banco Cameron Cty	1	20	Water Delivery System and Dike Cinstructon	$3,200	$160.0C
7	Rancho Viejo Cameron Cty	1	25	Water Delivery	$1,125	$45.0C
#1 SA	Willow Lake Hidalgo	6	38	improvements to maintain Water Control Structures, Culverts, and Water Delivery System	$9,900	$260.5:
9	Valadeces Banco Starr	1	35	Water Delivery System, and Land Agreement	$7,100	$202.8
4	Teniente Willacy	17	143	No water rights involved Ditch Plugs, Water Control Structures, and Delivery System	$6,400	$44.7
#2 SA	Cattail Lake Hidalgo	1	70	Water Delivery System	$9,200	$131.4
11	Los Velas Starr	1	15	Water Control Structure	$1,000	$66.6
	Total Tracts: 11	44	983		$84,425	$85.89

Estimated Costs for LRGV Wetland Restoration Projects

The information given in this document is taken from the projected costs for these wetland restoration projects as made by Steve Donovan in August of 1994.

Tract	Wetlands #	Total acreage	Infrastructure Work	Total Cost	Cost Per Acre
Ranchito	8	170	Water Control Structure system, and water delivery system	$13,000	$76.47
La Selva Verde	6	397	Water Control Structure system, ditch plugs, delivery system	$25,000	$62.97
La Gloria	1	20	Dike Installation, Water Control Structures	$3,500	$175.00
El Morillo Banco	1	50	Restore Water Delivery System, and Water Control Structure	$5,000	$100.00
Tahuachal Banco	1	20	Water Delivery System and Dike Cinstructon	$3,200	$160.00
Rancho Viejo	1	25	Water Delivery	$1,125	$45.00
Willow Lake	6	38	Water Control Structures, Culverts, and Water Delivery System	$9,900	$260.53
Valadeces Banco	1	35	Water Delivery System, and Land Agreement	$7,100	$202.85
Teniente	17	143	Ditch Plugs, Water Control Structures, and Delivery System	$6,400	$44.76
Cattail Lake	1	70	Water Delivery System	$9,200	$131.43
Los Velas	1	15	Water Control Structure	$1,000	$66.67
Total Tracts: 11	44	983		$84,425	$85.89

APPENDIX G

Irrigation Needs From 1995 Cooperative Farm Agreements

Farmer	Crop	Acreage		Projected Irrigation (In Acre Feet)
Beckwith, Arthur E.	Sorghum	290.3		290.30
	Sugar Cane	99.6		331.67
	Native Seeds	33.1		33.10
	Native Seedlings	3.7		3.70
			Total	658.77
Esacamilla, Jose	Sorghum	45.00	Total	45.00
Garza, Albert	Okra	40.00		80.00
	Native Seeds	9.00		9.00
	Native Seedlings	1.00		1.00
			Total	90.00
Hernandez, N.L.	Sorghum	87.00	Total	87.00
Leal, Fermin	Sorghum	222.20		222.20
	Native Seeds	18.00		18.00
	Native Seedlings	2.0		2.00
			Total	242.20
Mathers, Edward	Sorghum	194.10		194.10
	Native Seeds	9.70		9.70
			Total	203.80
Rodriguez, Herman	Sorghum	46.80		46.80
	Okra	35.00		70.00
			Total	116.80

Farmer	Crop	Acreage		Projected Irrigation (In Acre Feet)
Shofner, Charles	Sorghum	297.60		297.60
	Native Seeds	18.00		18.00
	Native Seedlings	2.00		2.00
			Total	317.60
Sparks, John	Sorghum	370.00		370.00
	Native Seedlings	20.00		20.00
			Total	390.00
Wells, Willie	Sorghum	59.50		59.50
	Native Seeds	11.00		11.00
	Native Seedlings	1.20		1.20
			Total	71.70
Zamora, Desiderio Jr.	Sorghum	14.60		14.60
		13.00		13.00
		1.60		1.60
			Total	29.20

Additional Farm Plans

Tract	Crop	Acreage	Projected Irrigation (In Acre Feet)
La Joya	Sorghum	1,033.00	1,033.00
	Native seeds and seedlings	100.00	100.00
Los Velas	Sorghum	290.00	290.00
Abrams West	Corn	230.00	345.00
	Native Seeds and Seedlings	50.00	50.00

Total Projected Irrigation Needs For Revegetation From 1995 Cooperative Farm Agreements	Total Projected Irrigation Needs For Crops From 1995 Cooperative Farm Agreements	Total Projected Irrigation Needs From 1995 Cooperative Farm Agreements
278.70	3,791.37	4,070.07

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Tamaulipan Brushland of the Lower Rio Grande Valley of South Texas: Description, Human Impacts, and Management Options

by

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Summary.

From June 1986 to March 1987, an extensive literature search and data synthesis were conducted on Matamoran District Tamaulipan brushland in the Lower Rio Grande Valley of south Texas, including physiographic, floral, and faunal descriptions, human impacts, and recent changes in native flora and fauna. The goal of this synthesis was to provide a single-source reference of historical review, land use planning, and management of brushland habitats and wildlife populations of the Lower Rio Grande Valley. Review of scientific journals, communication with professionals with expertise on the subject, and computer search by key words provided the majority of the material for our review. We also attempted to locate unpublished reports and other information not readily available. Our research included a trip to the area for personal observation of human impacts and discussion of current issues with U.S. Fish and Wildlife Service personnel in south Texas.

Tamaulipan brushland is a unique ecosystem, found only in south Texas and northeastern Mexico. Many plants and animals occur there that are not found elsewhere in the United States. Since the early 1900's, 95% of native Tamaulipan brushland has been cleared for agriculture, urban development, and recreation. In riparian areas, 99% of native brush has been destroyed. Clearing destroys habitat of native species of plants and animals in the Lower Rio Grande Valley, and it may cause extinction of many species. More than 100 pesticides are used on agricultural crops. These substances are incorporated into the food chain and are harmful or fatal to terrestrial and aquatic organisms. Water development on the Rio Grande has substantially reduced river flow, resulting in altered riparian habitats and additional brush clearing. Brush is destroyed in the Lower Rio Grande Valley by mechanical clearing, herbicides, and fire.

Current methods of land preservation (e.g., land purchase, easement, land lease and management agreements, and restoration of cropland to brushland) are reviewed, and constraints to each method are outlined. Fee purchase is most suitable for meeting U.S. Fish and Wildlife Service habitat and population objectives, but it cannot always be accomplished.

The resource protection and management strategy for the Lower Rio Grande Valley consists of five integrated approaches to address complex resource needs. They include: concentration of biotic community needs; maintenance of a wildlife habitat corridor; safeguarding of anchor units of large size; protection of strategically placed management units of smaller size; and the incorporation of about 20 habitat islands into the protection plan. Eighteen management suggestions that fit within this overall approach to protection and enhancement and that address the particular needs of small units of fragmented natural habitat are provided.

Interest in preservation of habitats and populations in the Lower Rio Grande Valley remains high, and development of refuges in the Valley remains a high priority of the U.S. Fish and Wildlife Service. Intense and continued local, regional, national, and international concern must be applied to implement safeguards that are needed to protect this unique and threatened habitat.

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Acknowledgments

We are grateful to the numerous individuals from Federal, State, and local agencies, universities, and private conservation organizations who assisted us during this project. We are particularly grateful for the guidance and input from R. Miller and D. Weeks of Oklahoma State University. We thank P. Zwank and O. Maughan of the U.S. Fish and Wildlife Service for critical review and technical editing of various drafts of this report. N. Fuller, Project Leader, Lower Rio Grande Valley National Wildlife Refuge Complex, and R. Schumacher, Refuge Manager, Lower Rio Grande Valley National Wildlife Refuge, provided constructive discussions about the Valley and critical review of various drafts of this report. Lastly, our report benefitted greatly from the contributions of time and hard-to-find reports from K. Collins of the U.S. Fish and Wildlife Service, Corpus Christi Ecological Services Office, and G. Waggerman and F. Potter of the Texas Parks and Wildlife Department.

Introduction

The U.S. Fish and Wildlife Service (USFWS) recognizes Tamaulipan brushland as a unique ecosystem that is found only in the Lower Rio Grande Valley (LRGV) of south Texas in the United States and northeastern Mexico. The LRGV is not really a valley but a delta, or a fertile plain, that slopes away from the Rio Grande (Johnston 1963; Rio Grande Valley Chamber of Commerce 1983; Lonard et al. 1988). The combination of climate, vegetation, and associated wildlife is unlike that in any other region of the United States. The vegetation is influenced by edaphic factors, and plant distribution can be correlated with geologic formations (Clover 1937). Characteristic vegetation of Tamaulipan brushland is dense and thorny. The most luxuriant brush is found on alluvial soil of the Rio Grande floodplain (Blair 1950), and large cedar elms (*Ulmus crassifolia*) dominate in some mesic areas. Vegetation in the xeric upland areas is mostly spiny shrubs and stunted trees (Clover 1937). A few characteristic plant species comprise the bulk of the brush vegetation. At present, some of the ubiquitous woody plant species are (Blair 1950): Texas ebony (*Pithecellobium flexicaule*); retama (*Parkinsonia aculeata*); granjeno (*Celtis pallida*); huisache (*Acacia smallii*); prickly pear (*Opuntia lindheimeri*); and mesquite (*Prosopis glandulosa*) – although prevalence of one mesquite may be due to human land abuse (Archer et al. 1988).

Dense brush in this unique ecosystem provides food, nest sites, and cover for many wildlife species. Neotropical genera of mammals, snakes, lizards, and salamanders reach the northern limits of their distribution in LRGV (Blair 1950). Two endangered felids, the ocelot (*Felis pardalis*) and jaguarundi (*Felis yagouaroundi*), use tracts of dense brush for cover and travel lanes (Tewes and Everett 1982). The U.S. distribution of many species of birds also is largely limited to native brushland in LRGV (USFWS 1980).

Human impacts on Tamaulipan brushland have been severe throughout this century and continue to threaten survival of this unique habitat. Since the 1920's, more than 95% of the original native brushland in LRGV has been converted to agricultural or urban use (USFWS 1980; Parvin 1988a,b). More than 90% of the riparian habitat on the United States side of the Rio Grande has been cleared (Collins 1984). It is estimated that 98% of the lush, subtropical region of the delta has been cleared in the United States (USFWS 1980), and a large percentage of similar habitat has been cleared in Mexico (Collins 1984).

Brush clearing, pesticide use, and irrigation practices associated with agriculture have had detrimental effects in LRGV. Water development, both for flood control and municipal use, has resulted in extensive clearing of brush, alteration of riparian habitats, and changes in water flow in the Rio Grande (Ramirez 1986). Population increases and associated urban expansion in LRGV have resulted in brush clearing and increased pollution (USFWS 1986). Industrialization has degraded water quality (USFWS 1986; Edwards and Contreras-Balderas, in press). Brushland habitats have been converted to rangeland with herbicides (Beasom et al. 1982), mechanical clearing (Bontrager et al. 1979), and fire (Hanselka and White, in press). Recreation, tourism, and hunting, especially for white-winged dove (*Zenaida asiatica*), net millions of dollars annually in LRGV (USFWS 1983); however, overuse can be deleterious to this brushland habitat.

Tamaulipan brushland is in need of immediate protection (USFWS 1985; Parvin 1988a,b). There are 55 plants on the list of endangered, threatened, or watch-list plants of LRGV (Table 1). Present trends suggest that the remaining LRGV brushland in private ownership will be developed within 5 yr (USFWS 1985). Most remnant tracts are small (usually < 40 ha [< 100 acres]) and scattered, such that habitat fragmentation threatens wildlife that is dependent on native brush (USFWS 1983). More than 500 vertebrate species are found regularly in LRGV, and the total could approach 700 if all marine and infrequent species are included (R. W. Schumacher, personal communication). Of these species, 67 are considered endangered or threatened by the U.S. Department of the Interior or the State of Texas (USFWS 1980). Tamaulipan brushland is a unique ecosystem found nowhere else in the United States, and urgent measures are needed to ensure preservation of unperturbed areas and restoration of previously degraded sites.

Description of Tamaulipan Brushland

Location and General Description

Blair (1950) classified the biotic provinces in Texas relative to topographic features, climate, vegetation types, and terrestrial vertebrates (excluding birds). The Tamaulipan Biotic Province of Texas is located south of the Balcones fault line (Blair 1950; Figure 1) and contains about 8 million ha (19.7 million acres) of semi-arid brushland (Lonard 1985). The boundaries of the Tamaulipan Biotic Province approximate those of the South Texas Plains vegetational area, also known as the Rio Grande Plain, which lies south of San Antonio between the Rio Grande and the Gulf Coast (Dallas Morning News 1986/87). Gould (1975a) classifies most of LRGV, which is comprised of Cameron, Hidalgo, Starr, and Willacy Counties (Figure 2), as a small part of the South Texas Plains vegetational area.

There is little moisture for plant growth in LRGV, and distribution of rainfall is often irregular (Table 2). Thus, vegetation must be drought-resistant (Crosswhite 1980). Blair (1950:103) described the area as follows:

Table 1. *Endangered, threatened, or watch-list plants of the Lower Rio Grande Valley.*

Family	Scientific name	Common name	TRPSC[a]	USDI[b]	TOES[c]	NPP[d]
Asteraceae	*Ambrosia cheiranthifolia*	Tamaulipan ragweed	E		WL	
	Dyssodia tephroleuca	ashy dogweed	E	E	E	E
	Grindelia oolepsis	plains gumweed			WL	WL
	Parthenium incanum	mariola			WL	
Euphorbiaceae	*Manihot walkerae*	Tamaulipan manihot	E		WL	
	Euphorbia antisyphylitica	candelilla			E	
	Adelia vaseyi	Vasey adelia			WL	
	Croton soliman	soliman			WL	
	Euphorbia golondrina	Boquillas spurge			WL	
Agavaceae	*Polianthes runyonii*	Runyon's huaco	E		E	
	Agave lophantha	thorn-crested agave			WL	
Liliaceae	*Anthericum chandleri*	Lila de los Llanos			WL	
Crassulaceae	*Sedum texanum*	Texas stonecrop	E		T	
Urticaceae	*Urtica chamaedryoides* var. *runyonii*	ortiguillo	E		WL	
Frankeniaceae	*Frankenia johnstonii*	Johnston's frankenia	E	E	E	E
Arecaceae	*Sabal mexicana*	Mexican palmetto			T	T
Taxodiaceae	*Taxodium mucronatum*	Montezuma baldcypress		E		E
Amaranthaceae	*Achryranthes aspera*	chaff-flower				E
	Iresine palmeri	Palmer's bloodleaf				T
Rutaceae	*Esenbeckia berlandieri*	jopoy				E
	Amyris madrensis	Sierra Madre torchwood				T
	Helietta parvifolia	Baretta				T
Sterculiaceae	*Ayenia limitaris*	Cameron ayenia				E
Violaceae	*Hybanthus verticillata* var. *platyphyllus*	Cameron green violet				E
Acanthaceae	*Justicia runyonii*	Runyon's water-willow				E
	Tetramerium platystegium	Torrey's tetramerium				T
	Dicliptera vahliana	red dicliptera				T
Cactaceae	*Echinocactus asterias*	star cactus				E
	Echinocereus reichenbachii var. *fitchii*	hair-covered hedgehog cactus				T
	Thelocactus bicolor var. *flavidispinus*	yellow-spined glory-of-Texas hedgehog cactus				T
	Coryphantha macromeris var. *runyonii*	Runyon's pincushion cactus				T

Table 1. *Continued.*

Family	Scientific name	Common name	TRPSC[a]	USDI[b]	TOES[c]	NPP[d]
Rubiaceae	*Cephalanthus salicifolius*	Mexican buttonbush				E
	Chiococca alba	David's milkberry				T
Nyctaginaceae	*Pisonia aculeata*	Devil's claw				T
Mimosaceae	*Acacia constricta*	mescat acacia				T
	Mimosa wherryana	Wherry mimosa				T
Fabaceae	*Coursetia axillaris*	Texas baby bonnets				T
Celastraceae	*Mortonia greggi*	Afinador				T
Capparidaceae	*Capparis incana*	Santa Ana capparis				T
Flacourtaceae	*Xylosma flexuosa*	brush-holly				T
Lythraceae	*Heimia salicifolia*	hachinal				T
Asclepiadaceae	*Asclepias prostrata*	prostrate milkweed				T
Verbenaceae	*Citharexylum spathulatum*	Mission fiddlewood				T
	Lantana microcephala	hammock lantana				T
	Citharexylum berlandieri	Tamaulipan fiddlewood				WL
Cyperaceae	*Eleocharis austrotexana*	Johnston's spikerush				WL
Bromeliaceae	*Tillandsia baileyi*	Bailey's ballmoss				WL
Polygonaceae	*Eriogonum greggii*	Gregg wild buckwheat				WL
Brassicaceae	*Lesquerella thamnophylla*	shrubleaf bladderpod				WL
Fabaceae	*Erythrina herbaceae*	coral bean				WL
Rosaceae	*Prunus texana*	peach bush				WL
Sapindaceae	*Cardiospermum dissectum*	Rio Grande balloon-vine				WL
Cochlospermaceae	*Amoreuxia wrightii*	yellowshow				WL
Turneraceae	*Turnera diffusa*	hierba del Veneda				WL
Boraginaceae	*Tournefortia volubilis*	twining tournefortia				WL

[a]TRPSC = Endangered (E) according to the Texas Rare Plant Study Center (1977; from USFWS 1983).
[b]USDI = Endangered (E) or threatened (T) according to the U.S. Department of the Interior (1987).
[c]TOES = Endangered (E), threatened (T), or watch-list (WL) according to the Texas Organization for Endangered Species (1983, 1987).
[d]NPP = Endangered (E), threatened (T), or watch-list (WL) according to the Native Plant Project (Everitt et al. 1986).

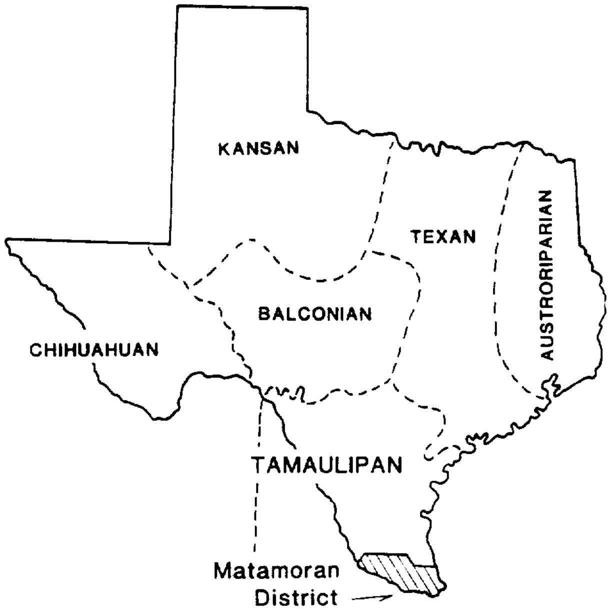

Figure 1. Boundaries of the Tamaulipan Biotic Province of southern Texas and northeastern Mexico (from Blair 1950).

Thorny brush is the predominant vegetation type of the Tamaulipan province of Texas. This brushland stretches from the Balcones fault line southward into Mexico. From the coast westward the brush thins out as available moisture declines. A few species of plants account for the bulk of brush vegetation and give it a characteristic aspect throughout the Tamaulipan of this state. The most important of these include [we have changed scientific names as revised by Correll and Johnson 1970]: mesquite (*Prosopis glandulosa*), various species of *Acacia* and *Mimosa*, granjeno (*Celtis pallida*), guayacan (*Porliera angustifolia*), cenizo (*Leucophyllum frutescens*), and white brush (*Aloysia gratissima*), prickly pear (*Opuntia lindheimeri*), tasajillo (*Opuntia leptocaulis*), and *Condalia* and *Castela*. The brush on the sandy soils differs in species and aspect from that of clay soils. Mesquite, in an open stand and mixed with various grasses, is characteristic of sandy areas. Clay soils usually have all the species listed above, including mesquite.

Blair believed that LRGV was best treated as a separate biotic district from the area of the Tamaulipan Biotic Province to the north and west (Figure 1). He designated this area the Matamoran District (named for the city of Matamoras just across the Rio Grande from Brownsville, Texas) and described it as follows:

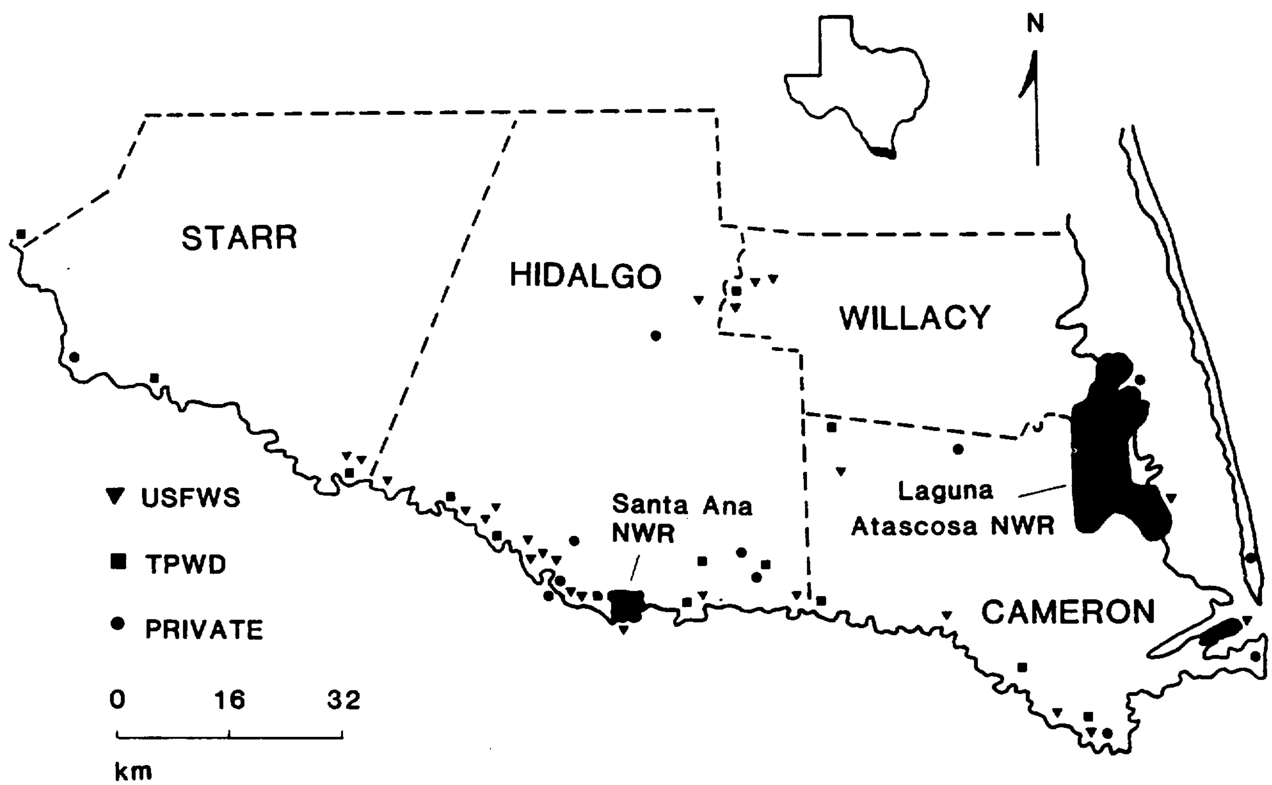

Figure 2. Counties, Federal refuges, State parks and wildlife management areas, and private sanctuaries in the Lower Rio Grande Valley, Texas.

> The southern part of the province is poorly drained....The brushlands of the Lower Rio Grande Valley, in Cameron, Willacy, Hidalgo, and Starr counties, are more luxuriant than the brushlands farther south, and they are characterized by the predominance of several species of plants that decrease in abundance northward. The most important of these species include [we have changed common and scientific names as revised by Correll and Johnson 1970]: retama (*Parkinsonia aculeata*), Texas ebony (*Pithecellobium flexicaule*), anacahuita (*Cordia boissieri*), and anacua (*Ehretia anacua*). The most luxuriant brush occurs on the immediate flood plain of the lower Rio Grande. Large elms (*Ulmus crassifolia*) dominate the flood plain in some places, and there is usually an alteration of elm dominants and brush species.

Climate in LRGV is semi-arid and subtropical (Table 2). Annual average rainfall (Crosswhite 1980) ranges from 38 to 76 cm (15 to 30 inches). In the Rio Grande plain, rainfall is highly erratic both seasonally and annually (Clover 1937). A single thunderstorm can comprise the entire monthly rainfall (Fleetwood 1973). Temperatures average about 10 °C (50 °F) in January and about 36 °C (96 °F) in July (Dallas Morning News 1986/87). Physical features vary for each county. Cameron County (Figure 2) is flat, with over 90% clay and loam soils and only 3% sandy soils, which are more typically found in coastal areas (Williams et al. 1977); Hidalgo County has 60% loamy soils, 22% sandy soils, and clayey and loamy soils in remaining areas, with flat areas near the Rio Grande and a more hilly northern region (Dallas Morning News 1986/87; Jacobs 1981); Starr County is rolling with loamy (76%), clayey and loamy (19%), and sandy (5%) soils (Dallas Morning News 1986/87; Thompson et al. 1972); Willacy County is flat, with a gradual slope to Laguna Madre, and loamy and clayey (73%) and sandy (16%) soils (Dallas Morning News 1986/87; Turner 1982).

Vegetation

Ecological characteristics of south Texas have resulted in a shrubland climax (Hanselka 1980). Mixed brush and acacia ridge associations were probably determined by climate, and species composition was modified by edaphic characteristics and past human perturbations (Hanselka 1980). In the 1700's, mesquite was present in riparian areas, canyons, and draws (Bogusch 1952). The Rio Grande was lined by a dense riparian thicket with trees as high as 21 m (66 ft) (Thornton 1977; Figure 3). Human disturbance prior to European colonization was minimal; most of the Native Americans lived in small bands on coastlines and river bottoms (Rappole et al. 1986). Spanish ships reached the coast in 1514, and the first explorers crossed LRGV in the late 17th century.

Vegetation of LRGV is unique because plants with western desert, northern, coastal, and tropical affinities are found in a relatively small area (Clover 1937). The total number of native plants found in LRGV is unknown, but estimates of native woody species range from 170 to 265 (Ideker 1985; Editor 1986). Clover (1937) divided vegetation that was designated as Tamaulipan brushland into two broad groupings: mesquital and chaparral. Crosswhite (1980) included a sacatal (grassland) element with the mesquital and chaparral. Mesquital was originally an open savannah-like bosque of large trees with a grassland understory generally comprised of curly mesquite grass (*Hilaria belangeri*). Because heavy grazing removed much of the grass, remaining dominants were cacti, brush, and stunted, bush-like mesquite. Chaparral consisted of a nearly impenetrable thicket of stiff, xerophytic, usually evergreen, brush (Crosswhite 1980) such as chaparro (*Zizyphus obtusifolius*), chaparro prieto (*Acacia rigidula*), and chaparro amargosa (*Castela texana*).

Tamaulipan brushland occurs on either side of the Rio Grande. On slightly higher, drier, and rockier sites, vegetation was originally chaparral. Flat, deep soils supported mesquite, as well as taller brush and a few drought-resistant, openly-spaced trees and associated grasses (Crosswhite 1980). Clover (1937) recognized three phases of mesquital. The mesquital-sacatal was comprised of open woods of mesquite and a pronounced understory of grasses and scattered shrubs. In the mesquital-nopalera, dense stands of prickly pear (nopal) replaced many of the shrubs and grasses. Finally, the mesquital-chaparral was comprised of mesquite and dense, thorny brush, which was often a result of heavy grazing (Clover 1937).

Presently, two general types of brush habitats exist in LRGV, riparian and scrub forests and upland thornscrub and thorn woodland. Riparian and scrub forests associated with the Rio Grande consist of several intergrading habitat types that produce taller vegetation than surrounding areas. This vegetation is important to wildlife as corridors throughout LRGV (USFWS 1984), as are "resacas," which are former streambeds now subject to repeated drying and inundation and often forming a long quiet pond or oxbow (Crosswhite 1980). Vegetation associated with resacas includes retama and huisache, which can withstand extended inundation as well as dry periods (Clover 1937). Upland sites contain the most extensive brush type remaining in LRGV, but the densest areas are limited to the western 30%–50% of Starr County. Upland areas are dissected by "arroyos," or riparian strips of dense brush known as "ramaderos." Ramaderos provide important nesting and feeding habitat for various wildlife species as well as

Table 2. *Climatic data from the four counties in the Lower Rio Grande Valley of south Texas.*[a]

Climate variable	Cameron	Hidalgo	Starr	Willacy
	County			
Temperature (F)				
Mean max. (July)	95	97	98	96
Mean min. (January)	51	49	48	50
Record high	108	110	115	107
Record low	21	18	7	19
Average date of freeze				
First in fall	12 December	8 December	7 December	11 December
Last in spring	4 February	7 February	16 February	6 February
Growing season (days)	341	327	314	331
Average monthly precipitation (inches)				
January	1.44	1.22	0.90	1.60
February	1.37	1.13	0.96	1.28
March	0.84	0.68	0.72	0.85
April	1.51	1.66	1.69	1.52
May	2.99	2.30	2.21	3.73
June	2.38	2.51	2.06	2.68
July	1.40	0.81	0.90	1.30
August	2.99	1.68	1.84	2.73
September	4.67	3.62	3.97	5.13
October	2.95	2.62	2.14	2.66
November	1.47	0.94	0.86	1.37
December	1.12	0.73	0.62	0.95
Annual precipitation (inches)	25.13	19.90	18.87	25.80

[a]Dallas Morning News (1986/87).

access routes to riparian brush along the Rio Grande (Collins 1984).

There are two plant species native to LRGV that are listed as endangered by USFWS (1987): Johnston's frankenia (*Frankenia johnstonii*) and ashy dogweed (*Dyssodia tephroleuca*). Numerous other plant species are considered either endangered or threatened by conservation organizations such as the Texas Organization for Endangered Species (Table 1). Texas ebony-anacua is recognized as an endangered habitat type (Diamond 1986); threatened habitat types include Texas ebony-snake-eyes (*Phaulothamnus spinescens*) and little bluestem-coastal live oak (*Quercus virginiana*) (Diamond 1986).

The USFWS currently recognizes 11 biotic communities in LRGV and contends that a community approach is necessary to identify and protect major wildlife/wildland resources (Figure 4). Each community is a unique component of the Matamoran District Tamaulipan biota (USFWS 1983; Collins 1984; Gilbertson 1988) and is described as follows (adapted from USFWS 1983, except where otherwise noted):

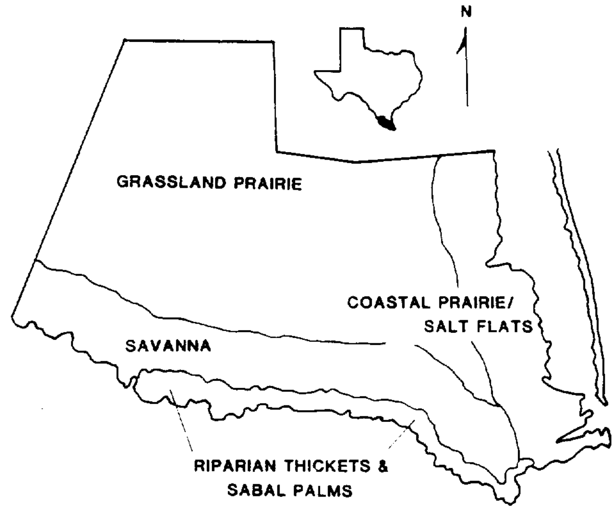

Figure 3. Historical vegetation of the Lower Rio Grande Valley (from Thornton 1977).

Chihuahuan Thorn Forest (Falcon Woodland)

This desert shrub community includes a riparian zone along the Rio Grande below Falcon Dam. The unique feature of this community is the riparian zone and its ecotone with the river on one side and desert scrub on the other. The riparian zone includes black willow (*Salix nigra*), Montezuma baldcypress (*Taxodium mucronatum*), Texas ebony, and mesquite. The upland has sotol (*Dasylirion texanum*), catclaw mimosa (*Mimosa biuncifera*), and blackbrush acacia. The brown jay (*Psilorhinus morio*), green kingfisher (*Chloroceryle americana*), ringed kingfisher (*Ceryle torquata*), belted kingfisher (*Ceryle alcyon*), and ferruginous pygmy owl (*Glacidium brasilianum*) occur in these thorn forests.

Upper Valley Flood Forest

This community consists of the small forested valleys of the Rio Grande between Falcon and Mission, Texas. Mesquite and granjeno are predominant woody species. These areas are important as traditional roosting areas for fall feeding flights of white-winged doves and are suitable habitat for many species of management concern for USFWS.

Barretal

The "barretal," or thicket, is dominated by the native citrus tree, *Helietta parvifolia*. This habitat is restricted to a narrow band of gravel and caliche (i.e., impermeable formations of calcium carbonate) ridges that form an ecotone with the floodplain (Clover 1937). The "barretal" is the only site in the United States where a native citrus occurs as a thicket. Other brush species in this community include (Crosswhite 1980) chaparro prieto, Tamaulipan Palo Verde (*Cercidium macrum*), chaparro amargosa, and junco (*Koeberlinia spinosa*). The area is important habitat for the elf owl (*Micrathene whitneyi*), the reticulate collared lizard (*Crotaphytus reticulatus*), and the Mexican burrowing toad (*Rhynophrynus dorsalis*).

Upland Thornscrub

Surrounding the Rio Grande delta and valleys within the Tamaulipan Biotic Province is the upland thornscrub. Typical woody plants are anacahuita and cenizo. The upland thornscrub is the most widespread habitat type in the province. Tracts of this habitat in proximity to the Rio Grande serve as wildland corridors connecting riparian habitats to uplands. Thornscrub is heavily used by raptors, particularly Swainson's hawks (*Buteo swainsoni*) and broad-winged hawks (*Buteo platypterus*), both of which migrate through LRGV in large numbers.

Mid-Valley Riparian Woodland

This community is essentially a bottomland hardwood site, with stands of cedar elm, Berlandier ash (*Fraxinus berlandieriana*), and sugar hackberry

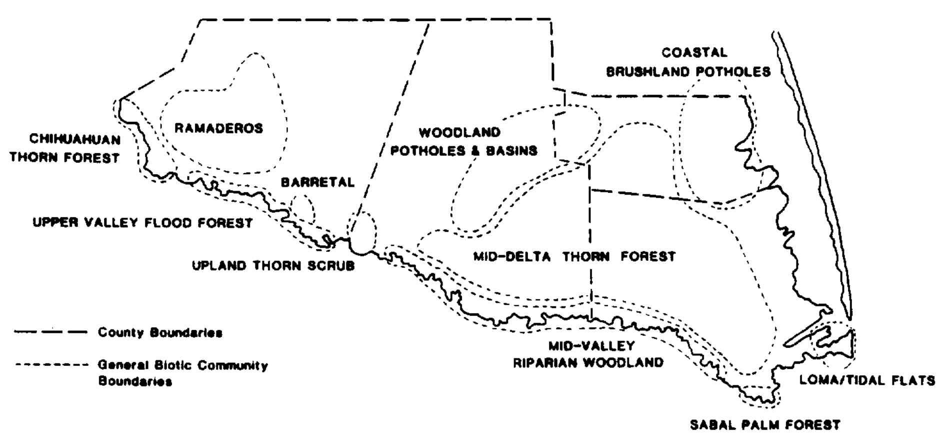

Figure 4. Biotic communities of the Lower Rio Grande Valley, classified to facilitate conservation of wildlife and floral resources (USFWS 1985).

(*Celtis laevigata*) mixed with mesquite/granjeno. The result is a dense, tall, canopied forest and greater availability of water and wildlife foods. This habitat is preferred by many rare birds; orioles (*Icterus* spp.), chachalacas (*Ortalis vetula*), and green jays (*Cyanocorax yncas*) may reach their greatest density in this habitat. Resacas in this habitat provide aquatic ecosystems that protect a unique group of Tamaulipan biota.

Sabal Palm Forest

The 149-ha (367-acre) USFWS tract in this community is known as "Boscaje de la Palma" and is located in the southmost bend of the Rio Grande near Brownsville. Remnant stands of Mexican palmettos (*Sabal mexicana*) – locally called sabal palm – found in a 1,418-ha (3,500-acre) area represent a remnant of a former 16,200-ha (40,000-acre) community. Palms were so prevalent that early Spanish explorers called the Rio Grande "Rio de las Palmas" (Crosswhite 1980). These stands are best described as palm-dominated, brush tracts with Mexican palmettos, tepeguaje (*Leucaena pulverulenta*), anacua, and Texas ebony as major woody associates. Characteristic fauna include ocelot, jaguarundi, lesser yellow bat (*Lasiurus ega*), hooded oriole (*Icterus cucullatus*), speckled racer (*Drymobius margaritiferus*), and northern cat-eyed snake (*Leptodeira septentrionalis*).

Clay Loma/Wind Tidal Flats

Three different communities form a "miniature ecosystem" of wooded islands in tidal flats that are periodically inundated by water from South Bay and the Gulf of Mexico. Lomas are formed from wind-blown silt or clay particles originally deposited in tidal flats by periodic flooding from the Rio Grande. When flats are dry and barren, prevailing winds deposit particles on dunes, which are normally covered with woody vegetation. Dunes may grow to 9 m (30 ft) above surrounding tidal flats. Rains and flooding can erode outer edges of the lomas. When wind or storm tides retreat, loma building begins again. Characteristic vegetation includes fiddlewood (*Citharexylum brachyanthum*) and Texas ebony on the lomas; borrichia (*Borrichia frutescens*) and salicornia (*Salicornia* spp.) on the flats; and black mangrove (*Avicennia nitida*) on South Bay. Representative vertebrates are the Texas tortoise (*Gopherus berlandieri*), long-billed curlews (*Numenius americanus*), and a unique hypersaline-tolerant population of oysters (*Ostrea equestris*).

Mid-Delta Thorn Forest

This community contains a mesquite and granjeno association mixed with Texas ebony, anacua, and brazil (*Condalia hookeri*) and was once an extensive thicket that covered most of the Rio Grande delta. There is < 5% of the original acreage left, mostly in fence rows, highway rights-of-way, canals, and ditch banks. Remnant tracts are small (normally < 40 ha [< 100 acres]) and scattered. Shrubs in this habitat form a tight interwoven canopy of 4-6 m (15–20 ft). The mid-delta thorn forest was used historically for nesting by white-winged doves.

Ramadero

Ramaderos are isolated riparian strips of dense brush that are associated with arroyos in upland areas of LRGV. Woody plant species that are found in ramadero habitats (e.g., granjeno, huisache, retama, brazil, and mesquite) can withstand periodic flooding (Collins 1984). Ramaderos are important nesting and feeding areas for wildlife and provide travel corridors to riparian brush along the Rio Grande for endangered felids. Common wildlife found in ramaderos includes: white-winged dove; plain chachalaca; white-tailed deer (*Odocoileus virginianus*); Harris hawk (*Parabuteo unicinctus*); reticulate collared lizard; and northern cat-eyed snake. Check dams in arroyos prevent water and nutrients from reaching ramaderos, which results in reduced height and density of plant species. It is estimated that 14,175 ha (35,000 acres) of ramaderos remain, mainly in Starr County (Collins 1984).

Wooded Potholes and Basins

This habitat includes the salt lakes of La Sal Vieja that are hypersaline due to evaporation and inflow from underground salt springs. Lakes are surrounded by brushlands that include many small freshwater wetlands or potholes. Some freshwater wetlands are resacas, but many occupy shallow basins, perhaps a result of an arid period when winds caused "blow-outs" in the sandy soil formations. During wet seasons, these wetlands are very productive; during wet winters, they function as greentree reservoirs for wintering waterfowl. Potholes are islands of wildlife habitat in an extensively cultivated region and are of high value to resident and migratory wildlife (Martin and Hehnke 1981; Guthery and Bryant 1982). Inland pothole wetlands are important for waterfowl production and overwintering, flood control, groundwater recharge, and water pollution abatement (Spiller and French 1986).

Coastal Brushland Potholes

The coastal influence separates this community from others. Wetlands in this area vary from freshwater ponds to brackish pools to saline estuaries. Vegetation also varies because of the saline influence and because of proximity to the Gulf of Mexico where microclimate is more stable than it is inland. In this biotic community, there are more days of cloud cover and precipitation and fewer extremes in temperature than in the other biotic communities. In some areas of the coastal brushlands, topography also is influenced by moving sand dunes; the leading edge buries the forest and the trailing edge uncovers dead vegetation. As these sand dunes move, depressions are sometimes formed. When these areas are wet, they receive heavy use by waterfowl and other wetland wildlife. Coastal brushland potholes may be prime habitat for the endangered ocelot and jaguarundi.

Defining the Area of Concern in LRGV

Some of the terms used herein to describe LRGV vegetational communities in earlier publications (e.g., chaparral) now have relatively unique definitions that render them inadequate to describe vegetation in south Texas. In addition, the term "Tamaulipan Biotic Province," although used extensively in the literature and colloquially to describe vegetational communities along the Texas–Mexico border, has broader application than just to the Rio Grande Delta, which is of major concern in this review. Two clarifications are therefore necessary. First, biotic communities of concern are limited to the 11 described previously. Those communities are treated herein as an inclusive list, and thus our discussion targets the communities of LRGV proper. (Detailed descriptions of plant communities throughout southern Texas can be found in Diamond et al. [1987] and Lonard et al. [1988]; Gilbertson [1988] compares historical descriptions, current USFWS community definitions, and Diamond et al.'s [1987] classification.) Second, the biogeographical area of interest is specifically the Matamoran District of the Tamaulipan Biotic Province (Figure 1; Blair 1950). In this report, the names "Matamoran District" and "Tamaulipan brushland" are given equal meaning because it is the brushland along the Rio Grande and other riparian areas that is of primary concern. The term "Tamaulipan Biotic Province" is used only when referring to the entire South Texas Plains (Rio Grande Plain) area.

Wildlife

Tamaulipan brushland provides important feeding, nesting, and cover habitats for many species. Brush clearing and other human activities thus have profound impacts on a variety of vertebrates and invertebrates in LRGV. Diversity of habitat types in LRGV results in a diverse vertebrate fauna, including species of subtropical, southwestern desert, prairie, coastal marshland, eastern forest, and marine affinities (International Boundary and Water Commission [IBWC] 1982a). About 700 vertebrate species have been found within the Matamoran District of LRGV. The USFWS considers 145 of these to be target species that require immediate protection (Table 3). Eighty-six vertebrate species in LRGV are considered endangered, threatened, or placed on a notice of review or watch-list by the U.S. Department of the Interior, the State of Texas, or the Texas Organization for Endangered Species (Table 3).

A number of vertebrate species found in LRGV are not found in any other region of the United States. The endangered ocelot and jaguarundi use extremely dense, impenetrable brush thickets for traveling and breeding (Goodwyn 1970; Davis 1974; Tewes and Everett 1982; Rappole 1988). Remnant brush tracts of this type are found only in extreme south Texas. Ocelots also are found in oak savannah habitat types in south Texas, which consist of open grassland, scattered groves, or "mottes," of live oak (*Quercus virginiana*), and a mid-story of live oak saplings and various thorn forest species (Rappole 1986). The ocelot once roamed eastern, central, and southern portions of Texas (Davis 1974), but today it exists mainly in south Texas brushland (Texas Parks and Wildlife Department [TPWD] 1986). Jaguarundi habitat in south Texas is poorly known but may be similar to ocelot habitat.

The blue spiny lizard (*Sceloporus cyanogenys*) is one of several Mexican species that reaches its northernmost distribution in LRGV (Scudday and Scudday 1976). Additionally, there are 21 bird species found in Mexico and Central America whose ranges reach their northern limits in LRGV (Winckler 1976); for example, least grebe (*Podiceps dominicus*), olivaceous cormorant (*Phalacrocorax olivaceus*), red-billed pigeon (*Columba flavirostris*), and brown jay. Other species, such as the black-bellied whistling-duck (*Dendrocygna autumnalis*), range further north, but populations that are dense enough to permit specific management reach their limits in LRGV.

The white-winged dove is the most important game bird in LRGV (Figure 5). In the early 1900's, when nesting habitat was abundant, populations of white-winged doves increased following introduction of irrigation and grain farming (George 1985). In the 1930's, extensive clearing for agriculture resulted in

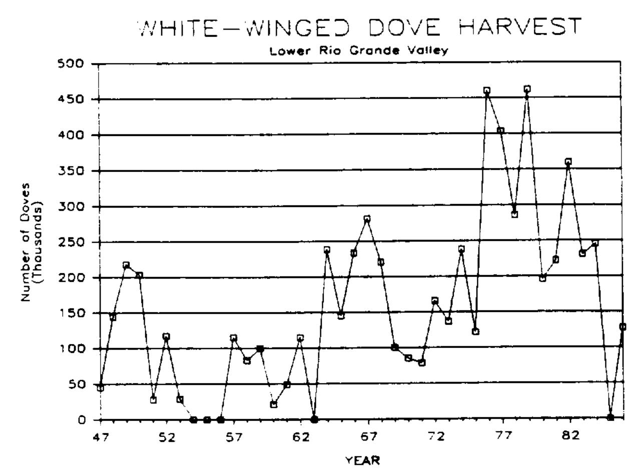

Figure 5. White-winged dove harvests from the Lower Rio Grande Valley, compiled from Cottam and Trefethen (1968) and unpublished data from the Texas Parks and Wildlife Department (pre-1976, hunter questionnaires; post-1976, mail surveys).

Table 3. *Endangered, threatened, watch-list vertebrates, and species of management concern of actual or potential occurrence in Lower Rio Grande Valley NWR (Lower Rio Grand Valley NWR 1987).*

Common name	Scientific name	USDI[a]	TOES[b]	TPWD[c]	LRGV NWR[d]
AVES					
least grebe	*Podiceps dominicus*				P
eared grebe	*Podiceps nigricollis*				W
American white pelican	*Pelecanus erythrorhynchos*				WB
brown pelican	*Pelecanus occidentalis*	E	E	E	C
olivaceous cormorant	*Phalacrocorax olivaceus*				P
anhinga	*Anhinga anhinga*				P
magnificient frigatebird	*Fregata magnificens*				C
reddish egret	*Egretta rufescens*			T	C
white ibis	*Eudocimus albus*				C
white-faced ibis	*Plegadis chihi*		T	T	
roseate spoonbill	*Ajaia ajaja*		WL		
wood stork	*Mycteria americana*	E		T	C
fulvous whistling-duck	*Dendrocygna bicolor*		T		C
black-bellied whistling-duck	*Dendrocygna autumnalis*				P
green-winged teal	*Anas crecca*				W
mottled duck	*Anas fulvigula*				P
northern pintail	*Anas acuta*				W
blue-winged teal	*Anas discors*				W
northern shoveler	*Anas clypeata*				W
canvasback	*Aythya valisineria*				W
redhead	*Aythya americana*				W
lesser scaup	*Aythya affinis*				W
ruddy duck	*Oxyura jamaicensis*				W
masked duck	*Oxyura dominica*		WL		P
osprey	*Pandion haliaetus*			T	WR
hook-billed kite	*Chondrohierax unicinatus*				P
American swallow-tailed kite	*Elanoides forficatus*		T	T	M
black-shouldered kite	*Elanus caeruleus*		WL		P
bald eagle	*Haliaeetus leucocephalus*	E	E	E	nP
common black-hawk	*Buteogallus anthracinus*		T	T	P
Harris' hawk	*Parabuteo unicinctus*				P
gray hawk	*Buteo nitidus*		T	T	P
roadside hawk	*Buteo magnirostris*				P
broad-winged hawk	*Buteo platypterus*				M

Table 3. *Continued*.

Common name	Scientific name	USDI[a]	TOES[b]	TPWD[c]	LRGV NWR[d]
Swainson's hawk	*Buteo swainsoni*				M
white-tailed hawk	*Buteo albicaudatus*		T	T	P
zone-tailed hawk	*Buteo albonotatus*		T	T	P
golden eagle	*Aquila chrysaetos*		T		nP
crested caracara	*Polyborus plancus*				P
merlin	*Falco columbarius*		T		WR
aplomado falcon	*Falco femoralis*			E	P
peregrine falcon	*Falco peregrinus*	E	E	E,T	M
prairie falcon	*Falco mexicanus*		T		nP
plain chachalaca	*Ortalis vetula*				P
northern bobwhite	*Colinus virginianus*				GS
scaled quail	*Callipepla squamata*				GS
sandhill crane	*Grus canadensis*				GS
limpkin	*Aramus guarauna*				P
piping plover	*Charadrius melodus*	E,T		T	M
northern jacana	*Jacana spinosa*		T		C
least tern	*Sterna antillarum*	E,T	E,T	E	C
black skimmer	*Rhyncops niger*		T		C
red-billed pigeon	*Columba flavirostris*		T		P
white-winged dove	*Zenaida asiatica*				P
mourning dove	*Zenaida macroura*				P
inca dove	*Columbina inca*				P
ruddy ground dove	*Columbina talpacoti*				P
white-tipped dove	*Leptotila verreauxi*				P
groove-billed ani	*Crotophaga sulcirostris*				P
ferruginous pygmy-owl	*Glaucidium brasilianum*		WL	T	P
elf owl	*Micrathene whitneyi*				P
common pauraque	*Nyctidromus albicollis*				P
buff-bellied hummingbird	*Amazila yucatanensis*				P
ringed kingfisher	*Ceryle torquata*		WL		P
green kingfisher	*Chloroceryle americana*				P
northern beardless-tyrannulet	*Camptostoma imberbe*		WL	T	P
Wied's crested flycatcher	*Myiarchus tyrannulus*				P
great kiskadee	*Pitangus sulphuratus*				P
Couch's kingbird	*Tyrannus couchii*				P
rose-throated becard	*Pachyramphus aglaiae*		WL	T	P

Table 3. *Continued.*

Common name	Scientific name	USDI[a]	TOES[b]	TPWD[c]	LRGV NWR[d]
green jay	*Cyanocorax yncas*				P
brown jay	*Psilorhinus morio*		WL		P
Mexican crow	*Corvus imparatus*				P
Chihuahuan raven	*Corvus cryptoleucus*				P
clay-colored robin	*Turdus grayi*				P
long-billed thrasher	*Toxostoma longirostre*				P
black-capped vireo	*Vireo atricapillus*			T	M
red-eyed vireo	*Vireo olivaceus* (ssp. *flavoviridis*)		WL		P
tropical parula	*Parula pitiayumi*		WL	T	P
golden-cheeked warbler	*Dendroica chrysoparia*		T	T	M
olive sparrow	*Arremonops rufivirgatus*				P
white-collared seedeater	*Sporophila torqueola*				P
Botteri's sparrow	*Aimophila botterii*		T	T	P
great-tailed grackle	*Cassidix mexicanus*				P
bronzed cowbird	*Molothrus aeneus*				P
hooded oriole	*Icterus cucullatus*				P
Altamira oriole	*Icterus gularis*		WL		P
Audubon's oriole	*Icterus graduacauda*				P
MAMMALIA[e]					
lesser yellow bat	*Lasiurus ega*		WL		
Coues' rice rat	*Oryzomys couesi*		T	T	P
eastern cottontail	*Sylvilagus floridanus*				GS
collared peccary	*Dicotyles tajacu*				GS
white-tailed Deer	*Odocoileus virginianus*				GS
black bear	*Ursus americanus*		T	E	P
coati	*Nasua nasua*		WL	E	P
coyote	*Canis latrans*				PS
cougar	*Felis concolor*		T		
ocelot	*Felis pardalis*	E	E	E	P
jaguarundi	*Felis yagouaroundi*	E	E	E	P
bobcat	*Felis rufus*				PS
jaguar	*Felis onca*	E	E	E	P
pygmy killer whale	*Feresa attenuata*		T	T	A
short-finned pilot whale	*Globicephala sieboldii*			T	A
killer whale	*Orcinus orca*			T	A

Table 3. *Continued.*

Common name	Scientific name	USDI[a]	TOES[b]	TPWD[c]	LRGV NWR[d]
false killer whale	*Pseudorca crassidens*			T	A
short-snouted spinner dolphin	*Stenella longirostris*		T		A
Blainville's spotted dolphin	*Stenella pernettensis*			T	A
rough-toothed dolphin	*Steno bredanensis*			T	A
Lacepede's bottle-nosed dolphin	*Tursiops nesarnack*		T		A
pygmy sperm whale	*Kogia breviceps*		T	T	A
dwarf sperm whale	*Kogia simus*		T	T	A
sperm whale	*Physeter catodon*	E	E	E	A
Cuvier's beaked whale	*Ziphius cavirostris*			T	A
Gervais' beaked whale	*Micropteron europeaus*			T	A
blue whale	*Balaenoptera musculus*	E		E	A
fin whale	*Balaenoptera physalus*	E		E	A
northern right whale	*Balaena glacialis*	E		E	A
Caribbean manatee	*Trichechus manatus*	E	E	E	P
REPTILIA					
American alligator	*Alligator mississippiensis*	T	T		nP
Texas tortoise	*Gopherus berlandieri*		T	T	
green sea turtle	*Chelonia mydas*	T	T	T	A
hawksbill sea turtle	*Eretmochelys imbricata*	E	E	E	A
loggerhead sea turtle	*Caretta caretta*	T	T	E	A
Kemp's ridley sea turtle	*Lepidochelys kempi*	E	E	E	A
leatherback sea turtle	*Dermochelys coriacea*	E	E	E	A
reticulated collared lizard	*Crotaphytus reticulatus*		T	T	
Texas horned lizard	*Phrynosoma cornutum*		T	T	
mesquite lizard	*Sceloporus gramniens*				P
speckled racer	*Drymobius margaritiferus*		WL	E	P
Texas indigo snake	*Drymarchon corais*		WL	T	
Mexican milk snake	*Lampropeltis triangulum*		T		
Ruthven's whipsnake	*Masticophis taeniatus*				nP
black-striped snake	*Coniophanes imperialis*		WL	T	P
northern cat-eyed snake	*Leptodeira septentrionalis*		WL	E	P
black-spotted newt	*Notophthalmus meridionalis*		WL	E	P
Rio Grande lesser siren	*Siren intermedia*		T	E	P
Mexican burrowing frog	*Rhynophrynus dorsalis*		WL	T	P
giant toad	*Bufo marinus*		WL	T	P

Table 3. *Continued.*

Common name	Scientific name	USDI[a]	TOES[b]	TPWD[c]	LRGV NWR[d]
Rio Grande chirping frog	*Syrrhophus cystignathoides*		WL	T	P
white-lipped frog	*Leptodactylus fragilis*		WL	E	P
Mexican treetoad	*Smilisca baudini*		WL	T	P
sheep frog	*Hypopachus variolosus*			T	P
PISCES					
fat snook	*Centropomus parallelus*		T		
river goby	*Awaous tajasica*			T	
blackfin goby	*Gobionellus atripinnis*			E	

[a]USDI = Endangered (E) or threatened (T), according to the U.S. Department of Interior (1987).
[b]TOES = Endangered (E), threatened (T), or watch-list (WL), according to the Texas Organization for Endangered Species (1984).
[c]TPWD = Endangered (E) or threatened (T), according to Texas Parks and Wildlife Department (1978, 1984).
[d]Unofficial status based on examination of range maps: Marine (A), peripheral from the south (P), peripheral from the coast (C), peripheral from the north (nP), migrates through LRGV (M), winter resident (WR), predator species (PS), waterfowl (W), waterbird (WB), and game species (GS).
[e]All cetaceans that are currently on lists for Texas are included, but few records exist from LRGV to determine precisely which species should be included on this list.

population declines (Batsell 1985; George 1985). White-winged doves have adapted to nesting in citrus groves that replaced native brush (Blankinship 1970), although densities are lower in these artificial habitats (George 1985). Additionally, groves sometimes are destroyed by periodic freezes. Prior to the 1984 freeze, the LRGV population of white-winged doves had stabilized at about 530,000 breeding birds, and the autumn flight was about 1 million birds (George 1985).

Habitats in LRGV also support a unique invertebrate fauna. Many species reach their northern limits of distribution in south Texas (Santa Ana National Wildlife Refuge [NWR], unpublished data). Invertebrate populations have received little research attention, thus, their status is largely unknown. However, habitat alterations likely have been detrimental to the invertebrate fauna of LRGV.

Unique Areas

The Land Protection Plan for the Lower Rio Grande Valley National Wildlife Refuge Complex has identified for intensive management a continuous brushland corridor along the Rio Grande anchored on the west by the Falcon Woodland and on the east by South Bay estuary (Figure 6); a large management unit in the Sal del Rey–La Sal Vieja area; and about 20 forested fragments scattered throughout the delta that range in size from 80 to 810 ha (200 to 2,000 acres). Ultimately, efforts by Federal, State, and private organizations should result in acquisition and conservation of about 101,250 ha (250,000 acres) in LRGV. There are several areas that are in need of immediate protection because of their relatively large size, undisturbed status, or high wildlife value (Figure 6). These areas are privately owned and are in various states of perturbation because of indiscriminant brush clearing or other human effects.

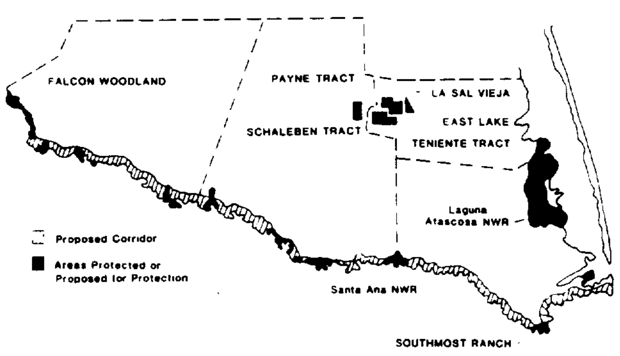

Figure 6. Unique, privately-owned areas in the Lower Rio Grande Valley, targeted for acquisition (USFWS 1983).

La Sal Vieja

La Sal Vieja is located at the northern edge of LRGV (Figure 6) and is one of the few areas in LRGV where appreciable amounts of native brush remain (Texas Nature Conservancy, undated). La Sal Vieja was ranked number 4 of the Top 100 Nationally Significant Fish and Wildlife Areas (USFWS 1983). Associated vegetation includes granjeno, brazil, prickly pear, mesquite, and Texas persimmon (*Diospyros texana*). Three large salt lakes are present, and water levels are maintained by underground salt springs and pluvial runoff. The area supports a diverse vertebrate fauna; more than 50 mammalian species are found at La Sal Vieja, including ocelot and jaguarundi, which may breed in the area (USFWS 1979). Diverse avifauna includes several peripheral Mexican species such as crested caracara (*Polyborus plancus*), groove-billed ani (*Crotophaga sulcirostris*), buff-bellied hummingbird (*Amazilia yucatanensis*), and great kiskadee (*Pitangus sulphuratus*). Wintering birds in the area include lesser scaup (*Aythya affinis*), ruddy ducks (*Oxyura jamaicensis*), black-bellied whistling-ducks, white pelicans (*Pelecanus erythrorhynchos*), and sandhill cranes (*Grus canadensis*). Approximately 6,000 pairs of white-winged doves nest on the site (USFWS 1979). An extensive amount of brush has been cleared from La Sal Vieja and immediate protection of remaining brush is critical (USFWS 1979).

Schaleben, Teniente, Payne, and East Lake Tracts

Changes in ownership of a variety of brushland tracts near La Sal Vieja (Figure 6) have occurred in the past year. The Nature Conservancy and the USFWS are actively acquiring lands in these areas, which attests to the priority placed on preserving these unique woodland pothole and basin communities. The Schaleben Tract is located in eastern Hidalgo County and encompasses 617 ha (1,526 acres), 85% of which is dominated by native brush. The Texas Nature Conservancy recently acquired 393 ha (970 acres) of the Schaleben Tract, which was conveyed to the USFWS (Nature Conservancy 1985; A. Schnapf, personal communication). The Teniente Tract, which is a combination of the Rudman, Beasley, and Ring Ranch tracts, encompasses 1,957 ha (4,835 acres) and is managed by the USFWS. The Payne (221 ha [546 acres]) and East Lake (710 ha [1,755 acres]) tracts are located in Willacy County (Figure 6).

There are numerous depressions on these tracts that fill seasonally with water. Vertebrate fauna is diverse; numerous species are threatened or protected in Texas or have restricted U.S. ranges; e.g., Rio Grande lesser siren (*Siren intermedia texana*), Texas tortoise, Texas indigo snake (*Drymarchon corais*), fulvous whistling-duck (*Dendrocygna bicolor*), and red-billed pigeon (*Columba flavirostris*). Both ocelot and jaguarundi occur on the area. All areas in the immediate vicinity of the tract have been cleared for agriculture and development (Neal 1983). Because the Schaleben and Teniente tracts are close, a protected wildlife corridor between them would increase total acreage of preserved brushland and allow movement of wildlife from one area to the other.

Falcon Woodland

The largest undisturbed remnant of tropical thorn woodland in the United States is adjacent to the Rio Grande and extends from below Falcon Dam downstream about 30 river km (19 mi) (Figure 6). Falcon Woodland contains 9,720 ha (24,000 acres) and is ranked number 5 of the Top 100 Nationally Significant Fish and Wildlife Areas (USFWS 1983). Habitat types in the area are: black willow–Berlandier ash (Rio Grande riparian), 20%; thornscrub association, 30%; and mesquite-granjeno association, 50% (USFWS 1979). The only known grove of Montezuma bald cypresses in the United States occurs in the Falcon Woodland. Three rare plants are known from the region: Gregg wild buckwheat (*Eriogonum greggi*), slashleaf heartseed (*Cardiospermum dissectum*), and *Amoreuxia wrightii* (Butterwick and Strong 1976; Smith 1976). Falcon Woodland provides habitat for > 300 species of birds, 50 species of mammals, 50 species of reptiles, and 20 species of amphibians (USFWS 1979). Many of these species are either peripheral to the United States or listed as threatened or endangered by Texas Organization for Endangered Species (USFWS 1979). Notable birds in the area include: brown jay (only nesting population in the United States); plain chachalaca; gray hawk (*Buteo nitidus*); Altamira oriole (*Icterus gularis*); and the ringed kingfisher (Smith 1976; Winckler 1976). Other uncommon wildlife species found at Falcon Woodland include (Scudday and Scudday 1976): the Mexican burrowing frog; giant toad (*Bufo marinus*); and Texas horned lizard (*Phrynosoma cornutum*). Endangered species that potentially occur in the area include: peregrine falcon (*Falco peregrinus*); ocelot; and jaguarundi. Clearing for cultivation and increased recreational development continue to threaten this area (USFWS 1979).

Southmost Ranch

Southmost Ranch, located southeast of Brownsville, Texas, on the Rio Grande (Figure 6), supports part of the remaining native Mexican palmetto community in the United States. Rio Grande thorn woodland also is present on the ranch. Southmost Ranch was ranked number 42 of the Top 100 Nationally Significant Fish and Wildlife Areas (USFWS 1983). Within the 259-ha (640-acre) ranch, 6 ha (15 acres) are dominated by Mexican palmetto, 61 ha (150 acres) have mesquite and acacia with some palmetto, and the remainder is cultivated fields and pastures (USFWS 1979). A variety of wildlife, including many peripheral species, exists in the Mexican palmetto forest community. Rare wildlife includes: the Mexican white-lipped frog (*Leptodactylus labialis*); Texas indigo snake; speckled racer; white-tipped dove (*Leptotila verreauxi*); tropical kingbird (*Tyrannus melancholicus*); white-collared seedeater (*Sporophila torqueola*); lesser yellow bat; and Mexican spiny pocket mouse (*Liomys irroratus*). The ocelot and jaguarundi may be present. Agricultural development and recreational use are primary threats to this area (USFWS 1979).

National Wildlife Refuges

There are presently three NWRs in LRGV. Santa Ana NWR and Lower Rio Grande Valley NWR form a complex, rather than two independent entities. Administrative facilities for both refuges are located in the Visitor Center at Santa Ana NWR (Figure 2). Santa Ana NWR is the centerpiece of the proposed corridor along the Rio Grande (Figure 6) and as such is located at the approximate middle of the corridor. The land base for LRGV NWR and the Land Preservation Plan for LRGV depend on and are part of the interpretive mission of the visitor center at Santa Ana NWR.

Santa Ana NWR in Hidalgo County is the smallest but most accessible refuge in LRGV (842 ha [2,080 acres]). It contains, however, one of the largest remaining tracts of subtropical riparian forest and native brushland in south Texas. The refuge is surrounded by a vast expanse of flat farmland that lacks wooded tracts (Kerlinger and Gauthreaux 1985). Santa Ana is in the Rio Grande floodplain, which was subjected to periodic overflow prior to construction of Falcon Dam in 1953 (USFWS 1986). Five National Champion trees, the largest of their species in the United States, have been found in the area: Berlandier ash, brazil, honey mesquite, guayacan, and Texas ebony (Dallas Morning News 1986/87).

Santa Ana NWR provides habitat for more endangered and threatened species than any other NWR in the U.S. Refuge System. More than 300 species of birds, 30 species of mammals, 50 species of reptiles and amphibians, and > 450 plant species occur on the refuge. The black-bellied whistling-duck, a neotropical species that reaches the northern limit of its breeding distribution in south Texas, breeds at Santa Ana (McCamant and Bolen 1979). Elms (*Ulmus* spp.) are the most important trees for nesting whistling-ducks (Delnicki and Bolen 1975). Altamira orioles also nest at Santa Ana (Pleasants 1981). Santa Ana is the most important of the few remaining roosting sites for migrant broad-winged hawks in LRGV. In 1982, 85,000 migrant broad-winged hawks were counted (Kerlinger and Gauthreaux 1985). Public facilities include a visitor center, more than 22 km (14 mi) of foot trails, photography blinds, and a 11-km (7-mi) tour road

(Dallas Morning News 1986/87). No hunting or camping is permitted.

Lower Rio Grande Valley NWR was established in 1980 and is comprised of 50 brush tracts that total approximately 11,104 ha (27,283 acres) scattered throughout Cameron, Hidalgo, Starr, and Willacy Counties (R. W. Schumacher, personal communication). Tamaulipan brushland is the typical vegetation. The primary objective of this refuge is to maintain and enhance populations of 145 vertebrate species of management concern (Table 3) through protection of Matamoran District habitat (USFWS 1986).

Laguna Atascosa NWR, the southernmost waterfowl refuge in the Central Flyway, was established in 1946. It contains 19,680 ha (48,597 acres) and is the largest refuge in LRGV. About 65,000 ducks winter on the refuge (USFWS 1986). Laguna Atascosa NWR contains coastal prairies, salt flats, and low vegetated ridges supporting thick, thorny shrubs (Fleetwood 1973). Habitat types of the refuge include: 9,720 ha (24,000 acres) of wetlands; 5,670 ha (14,000 acres) of coastal prairie; 3,280 ha (8,100 acres) of brushland; 405 ha (1,000 acres) of croplands; and 607 ha (1,500 acres) of grasslands and savannah (USFWS 1986). The refuge fauna includes 354 bird and 31 mammal species. Ocelot and jaguarundi recently have been sighted in the vicinity of Laguna Atascosa (S. Labuda, personal communication). In a 1980–81 survey of the area, 8 species of amphibians and 23 species of reptiles were collected (Scott 1982). Because of drought conditions during this period, 95% of the American alligators (*Alligator mississippiensis*) in LRGV were concentrated on the refuge (Scott 1982).

Laguna Atascosa NWR is accessible via walking trails, but parts of the bayside cannot be traversed easily. A visitor center is located in the refuge, and public refuge roads encompass much of the acreage that cannot be explored on foot. Deer hunting and fishing are allowed in designated areas, but camping is prohibited.

State and Private Lands

Tracts owned by TPWD and private conservation organizations are scattered throughout LRGV (Figure 2). The TPWD administers Las Palomas Wildlife Management Area, 13 tracts totaling 1,267 ha (3,129 acres) in Cameron, Hidalgo, Presidio, Starr, and Willacy Counties. Las Palomas provides nesting habitat for white-winged doves. Ocelot, jaguarundi, and cougar (*Felis concolor*) also have been sighted (Dallas Morning News 1986/87). Hunting for white-winged doves and plain chachalacas is allowed (Dallas Morning News 1986/87).

Bentsen–Rio Grande State Park is located southwest of McAllen adjacent to the Rio Grande. Much of the original subtropical vegetation in this 238-ha (587-acre) park has been preserved. Spanish moss (*Tillandsia usneoides*), which is important to nesting white-tipped doves (Boydstun and DeYoung 1987), grows on branches of riparian forest species (Gentry 1982). The avifauna of this park is diverse and includes many of the birds found at Santa Ana NWR. Elf owls nest in the area, and the hook-billed kite (*Chondrohierax unicinatus*) is occasionally observed (Lane 1983).

The National Audubon Society's Texas Sabal Palm Sanctuary, purchased in 1971, is south of Brownsville along the Rio Grande. The sanctuary preserves part of one of the largest remaining stands of the native Mexican palmetto. In 1940, the palm grove was > 40 ha (> 100 acres). By 1971, only about 13 ha (32 acres) remained. Currently, the sanctuary has a total of 70 ha (172 acres), including 49 ha (120 acres) of old fields that are being revegetated, and an 8-ha (20-acre) resaca (Miller 1985a). Many birds use the area (Lane 1983; Miller 1985a); for example, plain chachalaca, common ground dove (*Columbina passerina*), golden-fronted woodpecker (*Centurus aurifrons*), common pauraque (*Nyctidromus albicollis*), green jay, great kiskadee, Altamira orioles, and roseate spoonbills (*Ajaia ajaja*). Nearly 400 plant species have been identified in the palm grove. Falcon State Park, the Lower Rio Grande Valley Nature Center, Anzalduas County Park, and a few other sites further enhance the interpretive and visitation mission in LRGV.

Human Impacts

Since the early 1900's, native plants and plant communities in LRGV have faced threats from clearing for farm fields, improved range and pastures, expanding urban developments, and industrial expansion (Editor 1986). Water development projects also have resulted in clearing and inundation of native brush and alterations to the hydrology of LRGV. Since the 1920's, more than 95% of the original native brushland in LRGV has been converted to agricultural or urban use (USFWS 1978, 1980). Along the Rio Grande below Falcon Dam, 99% of the land has been cleared for agriculture and development (Miller 1985a). Rappole (1974) noted that trends in brushland clearing in south Texas were similar to clearing of tropical forests in Latin America. Significant stands of brush and woodlands in LRGV presently are found only in northern parts of Hidalgo and Willacy counties, along the Rio Grande corridor, and in the rangeland of Starr County (Collins 1984). A large percentage of similar habitat has been cleared in Mexico (Collins 1984). Gulf Coastal Plain vegetation in Mexico is rapidly being cleared, drained, and converted to farms (Judd 1985b).

Agriculture

Past and Present Trends

Crops. Agricultural clearing has had the greatest impact on native brush and thus plant communities and wildlife populations in LRGV. There were no mechanical means to remove brush in the early history of the region; brush clearing was done by hand. However, advances in land clearing and irrigation techniques in this century have increased pressure on native brush. Extensive clearing began in the late 1930's (USFWS 1980). More than 95% of the original brushland has been cleared, and approximately 2% of undisturbed brushy vegetation is being removed annually to make room for more crops.

The LRGV is one of the most intensively farmed areas in the United States (USFWS 1986). Rich delta soil of the Rio Grande and subtropical climate combine to provide some of the most productive farmland in the country (Miller 1985a). The initial surge of agriculture began in the early 1900's (Thornton 1977), but methods of operation and scale of production have intensified since the 1930's. Factors contributing to changes include: mechanization of farm operations; use of aircraft for applying seeds, fertilizers, and pesticides; and improved agricultural chemicals (Bonnen 1960). Currently, most of LRGV is in agricultural production. About 820,125 ha (2,025,000 acres) (75% of total) are used for crops, pasture, and rangeland (USFWS 1980), and about 437,400 ha (1,080,000 acres; 40% of total) of that are cultivated (Batsell 1985). Increasingly, agricultural land is being converted to other uses, including urban and rural residential development, tourism, and winter resorts.

The LRGV has a very long growing season; average annual frost-free period is 300 days (Table 2). Temperatures are generally mild, although damaging frosts can occur. In some parts of LRGV, improper irrigation or a high water table may bring salt to the root zone and injure or destroy citrus trees, or affect production of other salt-sensitive crops. However, soils are highly productive if properly managed (Bonnen 1960). The LRGV ranks high among the nation's intensified fruit-and-truck farm regions, and a large variety of vegetables is grown in LRGV (e.g., broccoli, cantaloupes, carrots, green peas, lettuce, spinach, tomatoes, and watermelons). Most agricultural crops are irrigated from the Rio Grande, although dryland crops such as cotton and grain sorghum are grown (Bonnen 1960).

Hidalgo County is one of the State's leaders in farm product sales with $320 million average annual income. Approximately 90% of farm cash receipts come from crops, principally cotton, citrus, grain, vegetables, and sugarcane. In 1985, 141,750 ha (350,000 acres; 35%) of Hidalgo County were irrigated. Dairy cattle, hogs, poultry, and horses are raised in Hidalgo County (Dallas Morning News 1986/87). Cameron County is also a leader in total farm income with about $91 million annually. Important crops include citrus, vegetables, and sugarcane. More than 68,040 ha (168,000 acres) (29%) of Cameron County were irrigated in 1985. Some cattle, hogs, and goats also are raised in the county (Dallas Morning News 1986/87). Average annual agricultural income for Starr County in 1985 was $63 million. Crops, including sorghums, cotton, and vegetables, provide 66% of the total income. In 1985, 8,100 ha (20,000 acres; 3%) were irrigated for vegetables. Beef cattle, hogs, sheep, and horses are raised in Starr County (Dallas Morning News 1986/87). Willacy County receives about $44 million average yearly income from agriculture. Cotton, sorghums, sugarcane, corn, vegetables, and citrus generate 90% of the total income. About 15,390 ha (38,000 acres) (10%) were irrigated in 1985. Cattle and hog production are included in agricultural income for Willacy County (Dallas Morning News 1986/87).

Grazing. In the early 1700's, Spanish explorers established missions and introduced grazing animals to the eastern edge of south Texas. By 1748, five ranching communities had been established on the Rio Grande. Settlers brought herds of cattle and horses to the area in the early 1800's (Drawe 1980), but interior grasslands did not receive heavy grazing pressure until after the end of the Mexican War in 1848 (Lehmann 1974). During the Civil War, when many ranch owners were absent, cattle were mostly free-ranging in south Texas. After the war, wild cattle were common on ranges. War veterans and others rounded up herds, drove them north to market, and invested profits into reconstructing ranches (Crosswhite 1980). Tamaulipan brushland and associated grassland provided needed cover and food for cattle (Crosswhite 1980). Cattle used brush habitat for warmth and protection during cold winters and for calving in spring. Adaptation of cattle to brush habitat must have begun when Spaniards first grazed herds along the Rio Grande (Crosswhite 1980). Eventually, animals from LRGV were used for stocking rangelands throughout the United States (Crosswhite 1980). Thus, the seed stock, tools, and techniques of managing semi-wild cattle were transplanted from LRGV throughout the American West (Lehmann 1974).

Detrimental Effects to Native Brush and Associated Fauna

Native brushland provides vital nesting and roosting habitat for white-winged doves (USFWS 1980). After reaching a population high of 12 million birds in the early 1900's, the white-winged dove population declined to about 500,000 birds in 1939, mainly because of destruction of nesting habitat for agricultural purposes (George 1985). More than 200,000 ha (493,827 acres) of nesting habitat of the white-winged dove were destroyed by 1942. Between 1939 and 1971, an additional 30,000 ha (74,074 acres) were cleared (Batsell 1985). Extensive brush removal and changes in food supplies during the past 50 yr have had detrimental effects on both spring breeding and autumn postbreeding dove numbers. Continued brush removal is a significant factor contributing to population fluctuations in white-winged doves (USFWS 1980).

Rapid agricultural development in Tamaulipas, Mexico since the mid-1970's probably has had an adverse effect on populations of white-winged doves. In 1953–54, total agricultural production for the area was 242,800 ha (599,506 acres). By 1980–81, total production jumped to 1,310,000 ha (3,234,567 acres). Most of the land placed into agricultural production was once Tamaulipan thornscrub (USFWS 1983). Despite land clearing, Mexican populations of white-winged doves (16–19 million) are expanding due to unrestricted availability of food and water; however, declines of Mexican white-winged doves similar to that in LRGV in the 1930's will likely occur unless steps are taken to preserve nesting habitat (George 1985).

In LRGV, 32%–50% of white-winged doves nest in citrus groves that replaced native brush, but their production is only about 30% of that in native vegetation (Miller 1985b; Waggerman 1986). Dense breeding colonies of doves in citrus groves and small remnant woodland tracts are subject to nest predation (Blankinship 1966) by great-tailed grackles (*Cassidix mexicanus*) and black rats (*Rattus rattus*). White-winged doves that nest in citrus groves also are disturbed by agricultural machinery and aerial pesticide spraying (Miller 1985b). Restoration of brushland habitat is the best approach to enhance dove populations in LRGV.

Ocelot and jaguarundi prefer dense thorn forest and brushland areas. Brush clearing continues to be the major limiting factor for feline populations in LRGV (Collins 1984; Rappole 1986; TPWD 1982; USFWS 1984). These animals also depend on densely vegetated travel corridors along resacas, ramaderos, and between brush tracts (Rappole 1988). Such corridors facilitate dispersal through an otherwise cleared landscape. Vegetation removal associated with "clean farming" and water storage, delivery, and drainage has negatively affected felid populations by preventing travel between remnant brush tracts.

For the most part, plain chachalacas are confined to remnant native brush tracts and resacas close to the Rio Grande and along the Arroyo Colorado. Agricultural fields often surround these brush tracts. Lower populations of plain chachalaca in the 1950's and 1960's were probably due to massive brush clearing in the 1940's (Waggerman 1979). Plain chachalacas are vulnerable to illegal harvest, which has increased with farm-related brush clearing and human population growth.

Intensive brush clearing can have a negative impact on white-tailed deer (Collins 1984; Inglis et al. 1986); highest deer densities are found in areas with 60%–97% total brush cover (Collins 1984). Brush elimination reduces vertical cover and decreases long-term quality of deer habitats (Fulbright and Beasom 1987). In large areas lacking vertical cover, deer populations are reduced from 50% to 65% (Inglis et al. 1986). Native brush along ramaderos provides shade, cover, and food for deer and other species (Collins 1984). As sizes of clearings in brushland increase, deer densities decrease.

Brush clearing has a negative impact on threatened plant species in LRGV (Table 1). For example, the baretta tree, a native citrus, is found in the same critical habitat as the rare reticulate collared lizard and the jaguarundi, and is threatened by clearing (Collins 1984). Mexican palmetto forests originally extended about 129 km (80 mi) inland from the mouth of the Rio Grande and south along the Mexican coast. Because of agricultural clearing, only two small groves remain in Texas (Miller 1985a). Two federally endangered plants, Johnston's frankenia and ashy dogweed face possible extinction from brush clearing and grazing in LRGV (Collins 1984; USFWS 1984).

Several previously abundant tree species survive in only a few locations in LRGV (Crosswhite 1980); for example, Texas lead tree (*Leucaena pulverulenta*), Texas ebony, anacahuita, anacua, Berlandier ash, gordolobo nightshade (*Solanum verbascifolium*), and Montezuma bald cypress, the tallest tree in the region (Crosswhite 1980). Although several of these trees have viable populations outside LRGV, continued survival of remnant populations in the valley may depend on preservation and restoration of brushland.

Little or no documentation is available on long-term perturbations to native flora and fauna associated with ranching in south Texas (Lonard 1985). Data from elsewhere, however, suggest that concentrations of cattle in native brushland along the Rio Grande would have several detrimental effects. In addition to the effects of grazing, cattle trampling damages native vegetation, especially seedlings. Trampling losses of simulated avian ground nests (Hoerth et al. 1983) ranged from 9% to 15% at a nest density of 1.0/ha (0.4/acre). Predation by striped skunks (*Mephitis mephitis*), coyotes (*Canis latrans*), and raccoon (*Procyon lotor*) on dummy wild turkey (*Meleagris gallopagao)* nests increased under various grazing systems (Baker 1978).

Cattle grazing has a significant effect on wildlife diversity and density in south Texas (Teer, in press). In California, chaparral communities that were being converted to grass, both lizards and small mammals were virtually absent from heavily grazed areas (Lillywhite 1977). Overgrazing reduces habitat quality for wildlife because plants preferred by livestock disappear (Drawe 1985); regeneration of vegetation decreases due to destruction of young plants. Cattle also can degrade wildlife habitat in and around small ponds by reducing foliar cover and vegetation height of shoreline plants (Whyte and Cain 1981). Cattle trample and feed on emergent pond vegetation, and disturb nesting pairs of marsh birds (Whyte and Cain 1979).

Pesticides

Past and Present Use

Pesticide use in LRGV began in the late 1940's and has increased with agricultural activity (Thornton 1977). Some pesticides that provide good pest and weed control in other parts of the country (i.e., the herbicides Treflan and simazine and insecticide Orthene in California) are of limited utility in south Texas, because higher rainfall results in greater insect and weed diversities (Felker 1984). Nevertheless, > 100 pesticides are used on agricultural crops throughout the region (USFWS 1986; Table 4), which provides a major pathway for pesticides to enter nontarget terrestrial and aquatic habitats (Lamoreux and Newland 1977). Pesticide contamination is widespread throughout inland waters of LRGV; concentrations of DDT, dieldrin, endrin, lindane, endosulfan, Guthion, and PCBs exceed 1976 EPA criteria for propagation of fish and wildlife (U.S. Army Corps of Engineers [USACE] 1982).

Agricultural pesticides are used year-round in LRGV, and drift and overspray from aerial applications occur periodically on NWR lands. Lower Rio Grande Valley NWR is especially susceptible to pesticide contamination because most of the 50 separate, relatively small tracts have agricultural land on 3–4 sides (USFWS 1986). Laguna Atascosa NWR also is surrounded by croplands that are treated with pesticides. Several species of bats that are known to occur at Laguna Atascosa NWR were not observed during a 1980–81 survey; extensive use of pesticides in the area may be responsible (Scott 1982). In 1983, 45 Franklin's gulls (*Larus pipixcan*) were found dead in Santa Ana NWR after they ate cicadas (Cicadidae) that were contaminated with azodrin (White and Kolbe 1985).

Adequate testing is needed to document pesticide contamination and its effects on wildlife (Moore 1969; Mulla 1963). Thorough assessment of effects on invertebrates and of long-term effects on the ecosystem require costly surveys. Although existing contamination can be documented, effects on populations are often unknown (T. Custer, personal communication), but likely pernicious.

Detrimental Effects to Aquatic Ecosystems

General Effects. Pesticides that are extensively used in LRGV probably enter aquatic systems directly as a result of aerial application or indirectly as runoff from treated fields (Judd 1985a). Wetlands in the Northern Prairie Region of north-central United States that are surrounded by cropland, as they are in LRGV, are often degraded by application of agricultural chemicals (Huckins et al. 1986). The herbicides atrazine and trifluralin and the organophosphate insecticide fonofos have been used in microcosm studies to simulate edge-of-field runoff (Huckins et al. 1986). Results suggested that Northern Prairie wetlands with row-cropped watersheds receive seasonal pesticide inputs that depend largely on rainfall frequency and runoff. For the compounds tested, probability of chronic pesticide effects on wetland aquatic organisms and biomagnification of residues through waterfowl food chains appears low (Huckins et al. 1986), but acute toxicity effects of atrazine and fonofos have been observed under worst case conditions (Huckins et al. 1986).

In another microcosm study in the North Prairie region, static acute toxicity tests with water fleas (*Daphnia magna*) and midges (*Chironomus riparius*) suggested that carbofuran, fonofos, phorate, and triallate are very toxic to aquatic invertebrates (Johnson 1986). Atrazine significantly reduced gross primary productivity and inhibited algal and macrophytic growth. Impact of atrazine, fonofos, and triallate on invertebrates and plants in microcosm experiments suggested that caution should be used in application of these chemicals in or near wetland habitats (Johnson 1986). The greater need for pest control in monoculture systems and increased agricultural chemical application with no-till agriculture both increase probability of pesticide runoff into wetland habitats (Huckins et al. 1986; Johnson 1986).

Pesticides that are currently used in LRGV can be very toxic to aquatic invertebrates. Invertebrates take from several weeks to several years to recolonize an area after they have been extirpated by contamination (Brown and Hunter 1985). Insecticide applications that reduce invertebrate abundance will have a secondary effect on breeding waterfowl. Lower density of invertebrates increases the energy cost for females and ducklings to acquire essential protein from invertebrates and thereby may reduce reproductive success and survival (Brown and Hunter 1985).

Aldrin-treated rice seeds have killed waterfowl, shorebirds, passerines, avian and mammalian scavengers and predators, fish, frogs, and invertebrates on the Texas Gulf Coast, and enhanced the accumulation of residues in soils (Flickinger and King 1972). Birds that depend on invertebrates as a primary food source have been killed by secondary poisoning (Flickinger and King 1972). For example, hundreds of young white-faced ibis (*Plegadis chihi*) died after adults fed them invertebrates collected from aldrin-treated rice fields (Flickinger and Meeker 1972). Consumption of dead and dying birds from contaminated rice fields often is fatal to predators and scavengers because residues are concentrated in higher trophic levels (Flickinger and King 1972).

Table 4. *Commonly used pesticides in the Lower Rio Grande Valley, Texas.*[a]

ORGANOPHOSPHATE INSECTICIDES	
Acephate	Fonofos
Azinphosmethyl (Guthion)	Malathion
Carbophenothion	Meta-Systox-R
Chloropyrifos (Dursban)	Methamidophos
Coumaphos	Methyl Parathion
Crufomate	Mevinphos (Phosdrin)
Demeton	Monocrotophos (Azodrin)
Diazinon	Naled (DiBrom)
Dichlorvos (DDVP)	Oxydemeton-Methyl
Dicrotophos (Bidrin)	Parathion (Ethyl)
Dimethoate	Phorate
Disulfoton	Phosmet (Imedan)
EPN	Phosphamidon
Ethion	Ronnel
Ethoprop	Sulfotepp
Famphur	TEPP
Fensulfothion	Trichlorfon (Dylox)
Fenthion (Baytex)	
N-METHYL CARBAMATE INSECTICIDES	
Aldicarb (Temik)	Carbaryl (Sevin)
Carbofuran (Furadan)	Landrin
Methiocarb	Methomyl (Lannate)
Oxamyl (Vydate)	Propoxur (Baygon)
ORGANOCHLORINE INSECTICIDES[b]	
Aldrin	Heptachlor
Benzene Hexachloride (BHC)	Heptachlor Epoxide
Chlordane **	Kelthane
Chlorobenzilate	Kepone (Chlordecone)
DDT (DDE, DDD)	Lindane *
Dicofol	Methoxychlor *
Dieldrin	Mirex
Endosulfan *	Strobane
Endrin	Toxaphene *
HERBICIDES	
2,4-D	Falone
2,4-DB	Glyphosate
2,4,5-T	MCPA
Ametryn	MCPB
Bromacil	MCPP
Cacodylic Acid	Monosodium Methanearsonate
Dalapon	Paraquat
Dicamba	Picloram
Dichlorprop	Silvex
Diuron	Simazine
EPTC	Tebuthiuron
Erbon	Terbacil
	Trifluralin

Table 4. *Continued.*

FUNGICIDES (citrus)	
Aldicarb (Temik 15G)	Oil
Benomyl (Benlate)	Sopp
Benomyl (Freshguard 113)	Thiabendazole (Fungicide conc. 2020)
Biphenyl	Thiabendazole (Fungicide conc. 1020 and 6)
Copper Ammonium Carbonate (Copper-Count-N)	Thiabendazole (Mertect 260)
Copper Hydroxide (Kocide 101)	Tribasic Copper

[a]Adapted from: Alexander 1985; Childress 1965, 1966, 1967, 1968; Cocke et al. 1980; Cole and Jackson 1985; Mutz et al. 1978; Scifres 1980a; Smith 1987.
[b]* still used in agriculture, ** still used in structural pest control. Many organochlorines have been withdrawn or agricultural uses severely restricted due to persistence in the environment, damage to endangered species, or potential to cause chronic health problems, reproductive system damage, and cancer (Alexander 1985; Mayer and Ellersieck 1986).

In LRGV, runoff from cultivated fields may concentrate pesticides and herbicides in permanent bodies of water. High concentrations adversely affect organisms found there (Thornton 1977). Judd (1985a) observed a die-off of the Rio Grande siren that was apparently due to insecticide contamination in a farm pond. Thornton (1977) observed a 65% reduction in number of amphibian species and a 51% reduction in number of reptilian species from levels previously recorded from LRGV. He suggested that large surface area: volume ratios of small anurans may make them vulnerable to pesticides and herbicides. Aerial applications of insecticides also can reduce the food supply of insectivorous amphibians and reptiles.

Organochlorine Pesticides including DDT. Ponds, lakes, and streams can act as settling basins for contaminated sediments that contain DDT and its metabolites (Ahr 1973; Lowe 1985). The parent compound (DDT) degrades to DDE, but degradation products are not removed from the system. DDT may be retained in sediment layers in these natural sinks, or relocated by post-depositional biological or mechanical processes that result in either a large amount of DDT released over a short time or in a sustained influx (Ahr 1973).

Organochlorine insecticides negatively affect mosquitofish (*Gambusia affinis*) and bullfrog tadpoles (*Rana catesbeiana*). Toxaphene was toxic for short periods at application rates of 0.56–1.12 kg/ha (0.5–1.0 lb/acre), but fish may have acquired tolerance to this compound because of its previous wide usage (Mulla 1963). Dieldrin (0.56 kg/ha [0.5 lb/acre]) showed high toxicity for several days. For mosquitofish, endrin and isodrin were the most toxic organochlorine insecticides; each was highly toxic at 0.112 kg/ha (0.1 lb/acre), with complete kill during the first 2–3 d and moderate mortality up to one week after treatment. At 0.56 kg/ha (0.5 lb/acre), endrin and isodrin caused complete kill up to 20 d post-treatment (Mulla 1963).

Bullfrog tadpoles exhibited moderate to high mortality at 0.56 kg/ha (0.5 lb/acre) DDT (Mulla 1963). Endrin, dieldrin, aldrin, and toxaphene each caused complete initial kill at 0.56 kg/ha (0.5 lb/acre). Endrin and dieldrin resulted in appreciable mortality of young tadpoles up to 6–7 d post-treatment. Toxic hazards associated with these insecticides may be markedly reduced by using minimum application rates or making as few applications as possible (Mulla 1963). Yet, such safeguards are hard to regulate.

In 1970, a study of Texas aquatic birds revealed significant decreases in eggshell thickness in 15 of 22 species (King et al. 1978). Although environmental factors and physiological processes that result in eggshell thinning are not well understood, DDE is most frequently correlated with eggshell thinning (King et al. 1978). Mean residues of DDT compounds ranged from 0.4 ppm in white ibis (*Eudocimus albus*) to 23.2 ppm in great egrets (*Casmerodius albus*) (King et al. 1978). Shell thickness reductions of 9%–15% were found in white pelicans, brown pelicans (*Pelecanus occidentalis*), and great blue herons and correlated with residues of DDT-family compounds. Residues in marine birds were generally lower and more uniform than levels in birds feeding in fresh and brackish water (King et al. 1978). Eggshell thickness of white-faced ibis was negatively correlated with DDE residues, and reduced reproductive success was observed at 3 ppm DDE

(Henny et al. 1985). Eggshells of American kestrels (*Falco sparverius*) dosed with DDE + dieldrin were 6%–23% thinner than controls (Wiemeyer et al. 1986).

DDT residues in avian eggs from south Texas (King et al. 1978) are comparable to levels that caused reproductive failures in wild populations elsewhere. Populations of five aquatic bird species have declined in Texas (King et al. 1978): for example, brown pelican, reddish egret (*Egretta rufescens*), white-faced ibis, laughing gull (*Larus atricilla*), and Forster's tern (*Sterna forsteri*). DDE and PCB levels that are not high enough to cause chronic poisoning and reproductive problems (King and Krynitsky 1986) also have been found in carcasses and eggs of olivaceous cormorants, laughing gulls, and black skimmers (*Rhynchops niger*).

DDT and dieldrin residues were especially high in eggs from colonies near agricultural areas where these insecticides were heavily used (King et al. 1978). Consistently higher levels of DDT and the greatest amount of shell thinning were found in eggs from the lower coast near intensively cultivated LRGV. DDE and dieldrin levels detected in egg samples are often related to food habits. Adult laughing gulls are attracted to recently sprayed fields by dead and dying insects and may even key feeding flights on spray planes (White et al. 1983c). King et al. (1978) suggest that in view of the great variation in reported toxicity of dieldrin to different wildlife species, egg residues > 1 ppm must be viewed as hazardous.

Shorebirds that wintered on mudflats at outlets of agricultural drains accumulated pesticides (White et al. 1983a). In south Texas, DDE, toxaphene, and dieldrin residues were detected in 95%, 22%, and 13% of the carcasses examined, respectively (White et al. 1983a). DDE accumulation of 12–68 ppm in 40% of long-billed dowitchers (*Limnodromus scolopaceus*) that were sampled was within the range known to impair reproduction, and may be a threat to sensitive raptor species (i.e., peregrine falcon) that prey on them (White et al. 1983a).

Detrimental Effects to Terrestrial Ecosystems

Commonly used insecticides for Texas cotton production include Bidrin, methyl parathion, and Fundal (Larson et al. 1975). An estimated 1.5 million kg (4 million lb) of insecticides are used annually on cotton alone in LRGV (Larson et al. 1975). Pesticides for boll weevil control could adversely impact birds, ocelot, and jaguarundi (USFWS 1986). In addition, cotton is usually grown in the same area year after year, which leads to an accumulation of resistant pesticides (Thornton 1977). Implementation of the Integrated Pest Management Program in LRGV in 1972 has decreased insecticide applications on irrigated cotton from 15 to 20/season to 6 to 12/season (USACE 1980). Additionally, short-season cotton production can reduce insecticide use by up to 39% compared to conventional production. This approach can minimize adverse effects of insecticides because amounts of potentially harmful residues are reduced (Larson et al. 1975).

Organophosphate and Carbamate Insecticides. Organophosphate insecticides, such as ethyl parathion and methyl parathion, and carbamate insecticides, such as Furadan, can be toxic to fish and wildlife (Custer et al. 1985; Flickinger 1986; USFWS 1986; Smith 1987). Negative effects are especially dangerous where wildlife congregate. Areas such as refuges may be the only remaining suitable habitat for wildlife in intensively agricultural areas like LRGV (White and Kolbe 1985).

Furadan 3G (3% carbofuran) is the only formulation that is registered by the EPA for control of the rice water weevil (*Lissorhoptrus oryzophilus*) in Texas rice fields. Furadan 3G in Texas rice fields has caused mortality to birds, fish, frogs, crayfish, earthworms, and nontarget insects (Flickinger et al. 1980). Rice seed also may be commercially treated with malathion insecticide, Difolatan 4 flowable fungicide, and Kocide-zinc (zinc-oxide) fertilizer, or malathion and Vitavax-R fungicide (Flickinger et al. 1986). Ethyl and methyl parathion also are commonly used on Texas rice fields (Custer et al. 1985). In south Texas, parathion application killed >70 geese (White et al. 1982), including 60 Canada geese (*Branta canadensis*).

Kills of 11 avian species (primarily migrant dickcissels [*Spiza americana*] and savannah sparrows [*Passerculus sandwichensis*]) have resulted from misuses of Furadan (e.g., applying more than the registered rate), but also from applications at registered rates (Flickinger et al. 1986). Compared with controls, brain cholinesterase (ChE) activity in 44% of the birds killed by Furadan in a Texas rice field was depressed 32%–85%, and Furadan residues in contents of alimentary tracts averaged 3.4 ppm (Flickinger et al. 1986). Although rice seeds had been treated with malathion prior to planting, they contained both malathion and Furadan upon collection from the study field, which suggested that the field was illegally treated with Furadan during planting. Flickinger et al. (1986) recommended that use and distribution of Furadan formulations 4F and 10G should be restricted to prevent recurring wildlife losses from legal, illegal, or careless treatments.

Ethyl and methyl parathion are used in Texas rice fields to control tadpole shrimp (*Triops longicaudatus*). In a study by Custer et al. (1985), no sick or dead vertebrates were found in or near treated fields. However, significant inhibition of brain ChE activity associated with methyl parathion exposure was demonstrated in at least one bird and one mammal species that used the area. Compared with controls, mean ChE activities of 43% of ring-necked pheasants

(*Phasianus colchicus*) and 37% of house mice (*Mus musculus*) were significantly inhibited. Neither treatment was acutely hazardous to wildlife in or near fields, but there was enough potential hazard to warrant caution in use of chemicals in rice fields, especially methyl parathion (Custer et al. 1985).

In a recent study of effects of organophosphate insecticides on brushland wildlife, no wildlife deaths were reported, and there were no overt effects on most of the animals studied. However, brain anticholinesterase (AChE) activity of great-tailed grackles and mourning doves were significantly lower than controls after application of azodrin, sulprofos + EPN-methyl parathion (Custer and Mitchell 1987). Effects of sub-lethal exposure to these insecticides were not evaluated. Future research on effects of organophosphate insecticides should investigate reproductive success and survival of brushland wildlife (Custer and Mitchell 1987).

Azodrin was implicated in a severe die-off from secondary poisoning in Israel (Mendelssohn and Paz 1977). Following azodrin application to control voles (*Microtus guenthera*) in alfalfa fields, 145 raptors were found dead. An estimated 300–400 birds of prey were destroyed on 8 km^2 (3.1 mi^2) within 3 mo. Other mortality included songbirds and mammals including jungle cats (*Felis chaus*) and feral pigs that died from direct contact with the pesticide or by eating contaminated foods. In LRGV, ocelot and jaguarundi could have been exposed to azodrin poisoning, because several poisoned Franklin's gulls were partially eaten by predators or scavengers (White and Kolbe 1985). Restriction or close regulation of such pesticides is needed in LRGV.

Organochlorine Insecticides including DDT. Although the EPA banned DDT in 1972, DDT family compounds persist in the biota (Saiki and Schmitt 1986). DDT has a half-life up to 17 yr and is concentrated exponentially in higher trophic levels (Ahr 1973). DDD and DDE are the two principal metabolites of DDT (Henny et al. 1982, 1985; Lowe 1985; Saiki and Schmitt 1986; White and Krynitsky 1986; White et al. 1983a; Wiemeyer et al. 1986). Studies suggest that insectivorous animals living in areas subjected to one DDT application retain a significant proportion of DDT for several months up to about 2 yr. Following this period, DDE constitutes nearly all residues (DeWeese et al. 1986). Presently, contamination comes from both legal and possibly illegal uses. DDT, dieldrin, and other persistent pesticides are still legally used in Latin America (King et al. 1978; White et al. 1981). DDE concentration in second year peregrine falcons returning from Latin America was significantly higher than DDE concentration in hatchling year birds enroute to Latin America (Henny et al. 1982).

Continued illegal use of DDT may be suspected if high levels of DDT contamination are found in animals (Lowe 1985). Recent but unpublished surveys of passerine birds, waterfowl, and reptiles in the Rio Grande and Pecos River drainages have shown high DDE concentrations. Because DDE concentrations have decreased in other parts of the country, and because some of the passerine species are year-round residents of south Texas, it is possible that clandestine use of DDT maintains high DDE concentrations in area wildlife (Lowe 1985). Western kingbirds (*Tyrannus verticalis*) that winter in Latin America accumulated significantly higher levels of DDE over a 2-mo period in both Texas and Mexico than was present upon arrival (White 1984). Some whiptail lizards (*Cnemidophorus* spp.) also had high DDE levels. These animals are nonmigratory and were collected near agricultural fields, which suggests that lizards were exposed to elevated DDE levels (White 1984; White and Krynitsky 1986). Whether contamination was recent or residual is presently unknown (White and Krynitsky 1986).

A study of organochlorine contaminants in 38 species of passeriformes in the western United States suggested that potentially harmful organochlorine concentrations are present in some western migrants. These contaminants pose an even greater hazard to avian predators, such as the peregrine falcon (DeWeese et al. 1986). Chemicals detected (> 0.05 ppm) in order of frequency were DDE, polychlorinated biphenyls (PCBs), hexachlorocyclohexane (HCH), heptachlor epoxide, oxychlordane, dieldrin, and toxaphene. DDE comprised 72% of total organochlorine concentration. Migrant insectivorous species contained higher DDE, PCB, and total organochlorine residues than omnivores or granivores. Thirteen species contained DDE concentrations (> 3 ppm) that were considered sufficient to inhibit normal reproduction of avian predators that feed on them (DeWeese et al. 1986).

DeWeese et al. (1986) found dieldrin, hexachlorobenzene, Mirex, and beta-nonachlor only in avian migrants. Species with higher DDE concentrations were contaminated with more kinds of organochlorines. Among migrants, insectivores were > 4 times more contaminated with DDE than omnivores. Among omnivores, migrants were > 6 times more contaminated with DDE than non-migrants. Differences in DDE residues among different migrants may be due to exposure while migrating or wintering in contaminated areas, or differences in metabolism and excretion of contaminants. Limited evidence in this study suggested that migrant birds acquire significant accumulation of DDE both in the southwestern United States and in parts of Latin America (King et al. 1978; DeWeese et al. 1986).

Fifteen of 38 Californian songbird species had at least one composite sample with > 3.0 ppm DDE, although there was not evidence of regional decline in any species (DeWeese et al. 1986). Many migratory species were as contaminated with DDE in 1980 as were starlings (*Sturnus vulgaris*) during the period when DDT was used regularly in the United States (1967–68). Wild populations of sensitive raptors may suffer reduced reproductive success from consuming DDE-contaminated food (DeWeese et al. 1986). DDE concentrations are considered a serious threat to peregrine falcons and other affected bird species (DeWeese et al. 1986).

Conclusion

Past pesticide use, both the types of chemical compounds and application rates, has been extensive and heavy in LRGV. Despite some legislative controls, present use continues to threaten native flora and fauna. As a result, pesticide accumulation in the biota remains a major concern in management of the Tamaulipan brushland.

Water Development

Present stream discharge characteristics of the lower Rio Grande are a result of both natural fluvial processes and anthropogenic activities. Because of the connectivity of fluvial systems, human-induced changes at any location can impact a wide area, especially downstream locations (Brooks 1986). Human modifications of the Rio Grande include: dams and reservoirs for flood control and hydroelectric power; floodway systems that remove water from the stream channel during peak flows; water diversions for irrigation, municipal, and industrial usage; and channel rectification and canalization (Shideler 1985; Judd 1985b; Figure 7). The existing United States interior floodway system in LRGV has a total length of 212 km (132 mi); Hackney Floodway below Anzalduas Dam and Mission Floodway above Anzalduas Dam join to form Main Floodway (IBWC 1973). In its delta, the Rio Grande is well entrenched in a comparatively narrow, meandering channel with generally steep banks (6–11 m [20–35 ft]) of silt and sand. Channel width ranges from 60–150 m (200–500 ft; IBWC 1983). Before flood control works were undertaken from 1900 to 1923 (Figure 7), the Rio Grande overflowed 23 times (Ramirez 1986). Peak flows caused flooding in Hidalgo and Cameron counties, and then collected in natural overflow channels and discharged into Laguna Madre and the Gulf of Mexico (IBWC 1983).

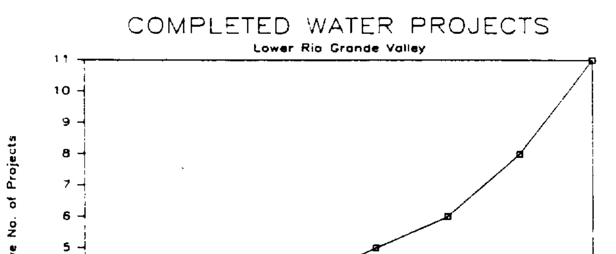

Figure 7. Completed water projects in the Lower Rio Grande Valley (adapted from Ramirez 1986).

The 1970's were a "water-rich" decade in LRGV (Edwards and Contreras-Balderas, in press). However, upstream impoundments on the Rio Grande in Texas and New Mexico, floodway systems that remove water from the stream channel during peak flows, and development of irrigated agriculture and municipal growth have reduced yearly average flow of the lower part of the river by 30%–50% (Edwards and Contreras-Balderas, in press). As a result, serious regional urban water shortages are predicted for 1985–90 (Texas Department of Water Resources [TDWR] 1981). Flow of the Rio Grande consists mainly of runoff from local rains, field runoff and water too salty for irrigation, and municipal effluent from Texas and Mexico (Breuer 1970).

Past Development

The first flood control structures in LRGV were build in the 1920's. Construction of Main Floodway extended to a point near Mercedes, TX, where the floodway naturally divided into two branches: North Floodway and Arroyo Colorado (IBWC 1973). In 1923, counties in LRGV initiated plans for construction of flood control levees. Inlets through levees allowed water to pass into floodways and the Gulf of Mexico. The LRGV Flood Control Project began in 1932 and was designed to protect against a 187,000 cubic feet per second (cfs) flood; however, a severe flood in 1932 demonstrated that the project was inadequate (Ramirez 1986). Since 1932, dams, floodways, and levees have been constructed to provide additional water storage and flood control in LRGV.

Falcon Dam, which has a capacity of 3,978,000 acre-ft (2,677,000 acre-ft for conservation storage and 1,311,000 acre-ft for flood control storage) was completed in 1953. In 1960, Anzalduas Dam was completed; the project included alteration of the floodway system along the Rio Grande. At Anzalduas Dam, > 80% of the United States share of floodwaters below Falcon Dam is diverted into Hackney Floodway, and the Mexico share of irrigation water is diverted into the main irrigation canal. Sixteen major pumping stations between Anzalduas Dam and Brownsville, TX, lift water from the Rio Grande into conveyance canals that serve irrigation districts and municipal-industrial water users in Cameron, Hidalgo, and Willacy Counties.

Retamal Dam, a diversion dam without flood storage capabilities, was built in the early 1970's. It diverts flood flows that exceed 20,000 cfs to the Retamal Floodway in Mexico. Several weirs in the Rio Grande below Retamal Dam and the Brownsville gaging station raise the water level and facilitate pumping into conveyance canals. Saline water from the San Juan irrigation district in Mexico enters the Morillo Drain above the point where 80% of U.S. diversions are made. The Morillo Drain Water Quality Improvement Project, completed in 1969, reduced salinity levels, but salinity from unknown source(s) between Falcon and Anzalduas dams continues to be a problem (Ramirez 1986).

Proposed Development

Since the early 1970's, a number of water projects have been proposed by the International Boundary and Water Commission and U.S. Army Corps of Engineers (Figure 7). These include: (1) extending and enlarging Hackney Floodway from Anzalduas Dam to Main Floodway and abandonment of the existing Mission Floodway (IBWC 1971); (2) increasing levee heights along existing North and Main Floodways (IBWC 1973); (3) altering new and existing drainage systems and increasing on-farm productivity in LRGV (e.g., the Lower Rio Grande Basin Flood Control and Major Drainage Project by the U.S. Army Corps of Engineers in cooperation with U.S. Soil Conservation Service) (Spiller 1981); (4) construction of a dike to increase diversion of first flows in Main Floodway to the Arroyo Colorado Floodway by 500 cfs before flows begin down North Floodway (IBWC 1982b); and (5) construction of channel storage dams on the Rio Grande downstream from Falcon Dam to conserve water for municipal and irrigation use in LRGV (IBWC 1983). Many of the proposals have been approved and implemented, although construction of channel storage dams remains a matter of debate.

Presently, the Rio Grande can safely carry 20,000 cfs water past Brownsville, TX, and Matamoros, Mexico (IBWC 1982a). However, two channel dams proposed by the Rio Grande Valley Municipal Water Authority could reduce water flow past these areas to 25 cfs (Ramirez 1986), which is the minimum flow required by the Texas Water Commission to dilute wastewater effluent discharged below the proposed dam site (Ramirez 1986). The project includes construction of a concrete dam (similar to Retamal Dam) at river kilometer 76.9 (mile 47.8) near Brownsville and modification of Retamal Dam from a floodwater diversion into a water storage structure. The dams would impound water to 8–22 m (26–72 ft) above mean sea level, respectively. Each dam would impound an additional 48 km (30 mi) of the Rio Grande. Resulting reservoirs would frequently empty and fill based on water demand (Ramirez 1986).

The Lower Rio Grande Basin Flood Control and Major Drainage Project is a 3-phase project that is designed to improve floodwater removal capabilities and agricultural drainage. The Army Corps of Engineers granted a permit (#11374) to Hidalgo County Drainage District #1 to conduct this project (USFWS 1981b). The Water Resources Development Act of 1974 authorized advanced engineering and design for Phase I. A feasibility report is complete, and the Army Corps of Engineers has recommended that Congress authorize construction (TDWR 1984).

Phase I of the project is a system of channels to remove floodwater from Hidalgo and Willacy counties; a large ditch will divert water into Laguna Madre. Phase II includes a lateral system of multipurpose channels and water-control structures in Hidalgo and Willacy counties. Phase III is an accelerated land-treatment program for Cameron, Hidalgo, and Willacy Counties that includes on-farm alterations such as subsurface tile drains (TDWR 1984; Perez 1986). The proposed project includes construction of 84 km (53 mi) of new earthen channels, 17 pumping stations, and alterations of 229 km (142 mi) of existing channels (USFWS 1981b).

Originally, the Army Corps of Engineers was planning Phase I; the Hidalgo County Drainage District #1, Army Corps of Engineers, and Soil Conservation Service were planning Phase II; and Soil Conservation Service was planning Phase III. Although the project consisted of 3 phases, the Army Corps of Engineers was only going to mitigate Phase I. The USFWS Ecological Services Office found this unacceptable. The Army Corps of Engineers has discontinued plans for the project; however, the Drainage District obtained a permit for the project in 1980. The Drainage District began digging from Laguna Madre inland but ceased because of lack of funds. Currently, an extension is in progress, and all 3 phases are covered by the permit granted to the Drainage District (K. Collins, personal communication).

The Army Corps of Engineers has granted two permits recently that necessitated review under the National Environmental Policy Act because of brush clearing (J. French, personal communication). Permit #11374 involved clearing 81 ha (200 acres) of brush, and mitigation only involved allowing the banks of the ditch to revegetate naturally between maintenance. However, "spill" will be dumped onto new growth of brush during ditch maintenance (J. French, personal communication). This action will inhibit brush regeneration. The Brownsville Navigation District was granted Permit #13942 to dredge and deepen the harbor. An oil terminal on an upland site affected 32 ha (80 acres) of brush that was part of the unique loma community. Mitigation for this impact was 1,873 ha (4,627 acres) of wetlands and lomas transferred to the LRGV NWR on a 40-yr lease (J. French, personal communication).

The Playa del Rio project, proposed for the Rio Grande delta, represents one of the largest potential threats to the ecological integrity of LRGV (Turner 1988). This project would degrade 4,858 ha (12,000 acres) of coastal habitat but also has the potential to impact upland areas, 66% of which are wetlands. The integrity of all natural areas adjacent to this project including South Padre Island, Redhead Ridge, the Loma Preserve, Brazos Island, Laguna Madre, South Bay, Boca Chica, and the last 32 km (20 mi) of the Rio Grande is threatened by the proposed Playa del Rio development. This project has the potential to negatively affect several endangered species; jaguarundi have been documented near the area, and ocelot may occur in suitable dense brush. Brown pelican and peregrine falcon also may be affected by the project. Several plants in the area are proposed for listing as threatened or endangered by USFWS. The Corpus Christi Ecological Services Office (USFWS) is presently gathering information for the biological assessment (J. French, personal communication).

Detrimental Effects of Development

Periodic flooding is a critical physical factor required to maintain natural conditions in subtropical, floodplain forests (Gehlbach 1981). Proposed channel dam construction and concomitant reduced flow could result in accelerated environmental degradation (Ramirez 1986). Some plants and unique communities along the Rio Grande already suffer from loss of annual or semi-annual floods that follow spring snow melt and autumn hurricanes (Editor 1986). Controlled release of water prevents normal flooding cycles of the river and contributes to replacement of mesic riparian woodland species (e.g., granjeno, cedar elm, and Montezuma baldcypress) with more xeric species (e.g., mesquite) (Ramirez 1986; Judd 1985b). Changes in the plant community can affect stability of natural channels, flood behavior, wildlife, and aesthetic resource values (Harris 1986). Roots of riparian trees help create the characteristic riffle and pool morphology of a stream, and irregularities in roots increase the roughness factor of the channel. This reduces bank erosion (Mason et al. 1984). Absence of floods also slows normal succession from grasses to palm woodlands in old farmland adjacent to Mexican palmetto forests (Miller 1985a).

In eastern Starr County, ramaderos contain the only significant brush stands left in LRGV; such areas are comprised of plant species that can withstand periodic flooding. Check dams on arroyos prevent significant amounts of water and nutrients from reaching ramaderos downstream, which reduces vegetational structure and density (Collins 1984). In an area where few native brush stands remain, ramaderos provide critical habitat to ocelot, jaguarundi, and other wildlife, and access to riparian brushland along the Rio Grande (Collins 1984). Destruction of ramaderos would have a negative impact on remnant felid populations.

Impoundments upstream from proposed channel dams would inundate riparian brush found only within the river channel. These narrow brush strips inside the channel connect with patches of more extensive riparian woodlands on top of the banks. Riparian brushland is critical for animals that travel the riparian corridor (Ramirez 1986).

Intermittent resacas depend on river flows, runoff, and precipitation for flushing and nutrient recharge. Flood control structures eliminate periodic floods and restrict recharge to rainfall and runoff (Perez 1986; Ramirez 1986). Cessation of flooding in LRGV has resulted in fewer resacas, ponds, and sloughs, which are excellent wildlife habitats (Judd 1985a).

Further reduction in flow of the Rio Grande would intensify negative impacts already associated with low river flow. Previously, large floods in LRGV periodically scoured the river bed and probably prevented silt deposits in the channel. Upstream dams may cause local increases in siltation due to moderated peak flows and restricted stream gradients (Edwards and Contreras-Balderas, in press).

Water that flows through natural stream channels is important habitat for fish and wildlife. Dam construction for water storage, diversion of water for irrigation, and municipal and industrial uses increase demands on available water resources and deplete natural stream flows (Orth and Maughan 1981a,b). Channelization destroys the natural stream community and speeds runoff. Regional water plans rarely quantify water needs for instream uses such as propagation of fish and wildlife, and flows are not reserved for these purposes (Orth and Maughan 1981b). Quantification of the effects of altered stream flow regimes on fish habitat is greatly needed (Orth and Maughan 1982). Presently, a major limitation of habitat assessment techniques is lack of quantitative information on microhabitat preferences of target species (Orth and Maughan 1982).

Changes in the aquatic fauna of the lower Rio Grande may be correlated with decreased stream flow, increased chemical pollution, or increased salinity (Edwards and Contreras-Balderas, in press). Two major fish communities have existed in the river over the past 130 yr. These consisted of an upstream, mostly freshwater community, and a downstream community with a mixture of abundant elements of upstream fauna and estuarine species (Edwards and Contreras-Balderas, in press). Recently, characteristic freshwater components of the upstream community have been replaced by exotic (i.e., nonnative) and estuarine forms. Reduced abundance of freshwater species may have been caused by an increased abundance of killifishes (Cyprinodontidae). These changes have been correlated with an apparent change in salinity regimes in upstream segments of the river. The presence of large numbers of young marine species indicates that the lower Rio Grande is being used as a nursery or spawning ground. Faunal changes ultimately have resulted in fewer fishes and less diverse aquatic faunal assemblages.

South Texas is particularly susceptible to the introduction of exotic fishes (Contreras-Balderas and Escalante-C. 1984) because of its subtropical climate and significant environmental perturbations and alteration of waterways (Courtenay et al. 1984). Exotics negatively affect native fauna and flora and reclamation of the preexisting ichthyofauna is usually impossible (Elton 1958; McDowall 1968; Zale 1984). Falcon Reservoir limits downstream penetration of longear sunfish (*Lepomis megalotis*) and redbreast sunfish (*L. auritus*) into lower Rio Grande environments, but they are common in upstream areas (Edwards and Contreras-Balderas, in press). Exotic blue tilapia (*Sarotherodon aureus*), which were first found above Falcon Reservoir in 1975, are now the dominant perciform and often the dominant taxon upstream from the Brownsville area. Tilapia populations are growing exponentially in the area and colonizing habitats in a more generalized fashion than nearly any other species (Edwards and Contreras-Balderas, in press).

Impoundments and reduced flow affect more than just fishes. For example, the rare green and ringed kingfishers are frequently observed with the more common belted kingfisher along a 20-km (12-mi) section of the Rio Grande below Falcon Dam (Lane 1983). Green kingfisher prefer shallow (< 15 cm [< 6.9 inches]) water for foraging; ringed kingfisher feed most often where water is deep (> 40 cm [> 16.7 inches]); and belted kingfishers actively feed in all water depths (Passmore and Thompson 1981). Downstream impoundments would reduce kingfisher habitat by decreasing water fluctuations.

A proposed flow of 25 cfs past Brownsville, which would result if the two channel dams were built, is 3% or less of average seasonal flow (Ramirez 1986). That flow is probably inadequate to sustain current levels of fisheries in the estuarine reach of the Rio Grande. Estuarine finfish and shellfish use the river mouth as a nursery area and depend on cyclic highs and lows of riverine flows (Ramirez 1986). White shrimp (*Penaeus setiferus*) is the most important commercial invertebrate in the tidal parts of the Rio Grande (Breuer 1970). White shrimp and brown shrimp (*P. aztecus*) need freshwater flows in the estuarine portion of the Rio Grande for postlarval and juvenile development (Breuer 1970). Brackish conditions that are caused by freshwater inflow exclude predatory adult finfish that prefer higher salinities. Freshwater inflows also transport nutrients and detritus into the lower river, which are necessary for development of juvenile shrimp (Breuer 1970).

Atlantic croaker (*Micropogon undulatus*) is the most important commercial marine fish off south Texas and uses the tidal Rio Grande as a nursery. Other species that form the basis for local sport and commercial fisheries include: spotted sea trout (*Cynoscion nebulosus*); black drum (*Pogonias cromis*); redfish (*Sciaenops ocellatus*); and snook (*Centropomus* spp.) (Breuer 1970). Bay anchovies (*Anchoa mitchelli*) and blue crab (*Callinectes sapidus*) are other important species that use the Rio Grande. Important freshwater game fishes that are affected by change in amount, timing, and quality of streamflows include (Ramirez 1986) channel catfish (*Ictalurus punctatus*), blue catfish (*I. furcatus*), and green sunfish (*Lepomis cyanellus*). Impact of channel dams on estuarine finfish and shellfish at the mouth of the Rio Grande would be especially critical during droughts, which occur about once every 5 yr (Ramirez 1986).

Increased deterioration and habitat loss would be expected with enlargement of existing drainage facilities and establishment of new ones. Although existing endangered species in LRGV would not be initially affected by the Lower Rio Grande Basin Flood Control and Major Drainage Project (USFWS 1981a,b), other negative impacts would occur. Surface waters redirected to channels would not flow into wetlands. Water levels would be reduced along with the amount of waterfowl habitat. In addition to direct effects of habitat loss, reduction of wetland areas also may increase potential for disease such as fowl cholera (Bolen and Guthery 1982). Concentrations of large numbers of waterfowl on relatively small areas of surface water probably enhances disease transmission; infected migrants may reintroduce disease each winter (Bolen and Guthery 1982). Connecting wetlands that are filled by land leveling would be permanently lost. Mitigation proposed by the Army Corps of Engineers, such as dredging remaining wetlands and stocking with game fish, are inadequate to offset wetland losses. These procedures would lower primary productivity and reduce value of wetlands as wildlife feeding areas (Spiller 1981). Wetlands also slow agricultural runoff and allow agricultural pollutants (e.g., pesticides and fertilizers) to break down before entering Laguna Madre (Spiller and French 1986). Future losses of areas with such high ecological values must be avoided.

Projects that involve construction or modification of canals also result in water quality deterioration (Espey, Huston, and Associates 1977, 1979; USACE 1980). Sediments and contaminants are released whenever the bed and banks of a channel are disturbed by machinery used in flowing water (Brooks 1986). Redistribution of contaminants increases exposure to the biota because pesticide-laden sediments are resuspended by dredging and increased flows within canals (Perez 1986). Dredged sediments that are disposed of along canal borders also expose terrestrial species to contaminants (Perez 1986).

Irrigation

Most irrigation systems in LRGV were developed by private capital and initiative (Ramirez 1986). In the early 1900's, land developers in LRGV purchased large tracts of land along the Rio Grande. Construction and operation costs of irrigation systems were paid by developers through land sales and water delivery charges to customers. In the early 1920's, irrigation districts were organized in LRGV, and farmers bought irrigation systems from developers (Perez 1986; Ramirez 1986). Old districts were reorganized into water improvement, irrigation, and drainage districts. Currently, there are 33 local water management institutions in LRGV.

More than 70% of total water consumption in LRGV is for irrigation (TDWR 1984; Figure 8). Irrigation systems require construction of ditches, canals, and weirs to provide controlled flooding (Rappole et al. 1986). The primary source of irrigation water is surface water from the Rio Grande. Water removed for irrigation does not reenter the river as "return flow" but rather flows into floodways and irrigation systems and eventually into Laguna Madre, or evaporates (Edwards and Contreras-Balderas, in press).

Flat topography and inadequate inland drainage lead to water-logged soils and salinity problems in most of LRGV (Spiller 1981; TDWR 1984). The high water table allows dissolved salts to rise through the soil and enter the crop root zone. If water with dissolved salts reaches the surface, it evaporates and leaves a salt deposit (Box and Bennett 1959) that can reduce agricultural productivity (Spiller 1981). Application of saline irrigation water from the Rio Grande can cause soil to become critically saline (Perez 1986) and render it unsuitable for agricultural crops. Cultivated fields that are not allowed fallow periods of a few years have an effective production life of only 15–30 yr. Natural plant communities are adapted to local edaphic and climate regimes and do not suffer from salt build-ups (Rappole et al. 1986) because of deep root systems, soil integrity, and protection of soil from direct exposure to sun (i.e., baking, destruction of microflora), rain (i.e., leaching, runoff), and wind (i.e., loss of topsoil).

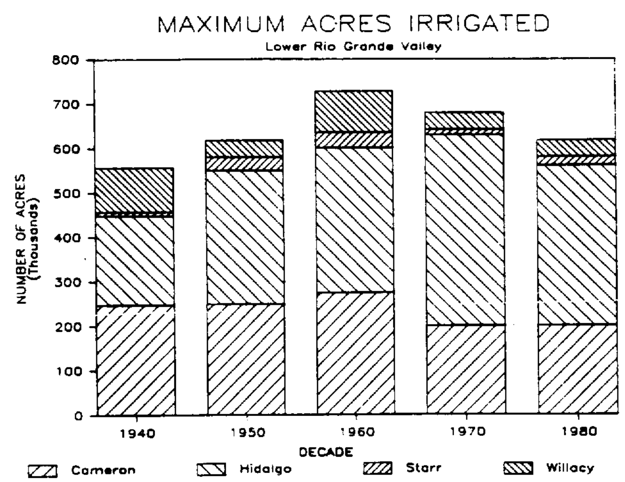

Figure 8. Maximum acres irrigated/decade in each county of the Lower Rio Grande Valley.

Detrimental Effects of Irrigation

Contaminants are distributed throughout LRGV by existing irrigation systems (Black and Veatch Consulting Engineers 1981b). In a study pertinent to the concerns in LRGV, Saiki and Schmitt (1986) investigated organochlorine residues in bluegills (*Lepomis macrochirus*) and common carp in California to determine if pesticide contamination was more prevalent in downstream sites exposed to irrigated agriculture than nonirrigated upstream sites. Samples of both species from the two areas contained p,p'-DDE residues, and chlordane, p,p'-DDD, p,p'-DDT, and dieldrin were present in both species at one or more sites. However, concentrations of most organochlorines in fishes increased from upstream to downstream. Water quality variables influenced by irrigation return flows (e.g., conductivity, turbidity, and total alkalinity) also increased from upstream to downstream and were significantly correlated with organochlorine residue levels in fishes (Saiki and Schmitt 1986).

Subsurface tile drainage systems have been proposed as mitigative techniques to offset increases in contaminant levels in surface waters (USACE 1982). However, turbidity from suspended sediments in drainage systems would reduce water quality. Additionally, such sediments can be laden with contaminants that are associated with agricultural pesticide application and urban runoff (Spiller 1981). In California, subsurface tile drainage systems were installed in parts of the San Joaquin Valley to remove excess groundwater and allow application of fresh water to leach salts from the soils (Saiki 1985a,b). Tile drainage water contained heavy metals, boron, selenium, and other organic elements that are toxic to fish and wildlife at high concentrations (Saiki 1985a).

Sediment samples from Laguna Atascosa NWR in LRGV have shown elevated selenium levels (USFWS 1986). Selenium is an essential element for growth and proper functions of organisms, but it is toxic to animals at 0.1 mg/kg–10 mg/kg in food (Black and Veatch Consulting Engineers 1981a; Saiki 1985b). Animals can accumulate toxic levels of selenium by eating contaminated foods (Saiki 1985b). In California, forage organisms exposed to subsurface tile drainage water contained high concentrations of selenium; mosquitofish and various aquatic plants had up to 370–390 μg/g dry weight, respectively (Saiki 1985a).

Selenium concentrations increased to toxic levels from water to plants to animals (Saiki 1985a). Selenium can be transferred from female bluegills to offspring and is known to cause reductions of fish populations in selenium-enriched reservoirs (Gillespie and Baumann 1986).

Severe reproductive impacts have been found in aquatic birds nesting on irrigation drainwater ponds in the San Joaquin Valley, CA (Ohlendorf et al. 1986). Of 347 nests studied through late incubation or hatching, 40.6% had at least one dead embryo and 19.6% had at least one embryo or chick with obvious external abnormalities. Deformities were often multiple and included missing or abnormal eyes, beaks, wings, legs, and feet. Brain, heart, liver, and skeletal anomalies also were present. Mean selenium concentrations in plants, invertebrates, and fish from drainwater ponds were 12–130 times those at a nearby control area. Bird eggs and livers also contained elevated levels of selenium. Aquatic birds may experience similar problems in areas where selenium occurs at elevated levels in soil or water (Ohlendorf et al. 1986). Selenium levels > 11 ppm were found in 6 out of 10 samples from laughing gulls in Galveston Bay, TX; reproduction may be impaired at this contaminant level (King and Cromartie 1986).

Floodway Systems into Laguna Madre

Originally, Arroyo Colorado was an arm of the Rio Grande that branched from the river below Mission, TX. Now, North Floodway and Arroyo Colorado are the primary source of fresh water to lower Laguna Madre. Arroyo Colorado also receives much of the municipal, agricultural, and industrial wastes of LRGV (Espey, Huston, and Associates 1977) and serves as an inland waterway and a recreational area for boating and fishing (Bryan 1971). In a 2-yr period, every organism analyzed (107) from Arroyo Colorado contained DDT, and 84 contained either dieldrin or endrin or both (Bryan 1971). DDT and its metabolites also were found in water and sediments. Oyster tissue samples averaged 0.294 ppm DDT; menhaden (*Brevoortia* spp.) averaged 0.977 ppm DDT at kilometer 11 (mile 7) and 3.82 ppm DDT at kilometer 40 (mile 25); and spotted seatrout ovaries and eggs averaged 4.17 ppm DDT and 2.93 ppm DDT, respectively. White et al. (1983b) found that freshwater fishes in Arroyo Colorado were highly contaminated with DDE and toxaphene residues compared with fishes from other areas in LRGV. Both DDE and toxaphene ranged up to 31.5 ppm wet weight in whole fish (White et al. 1983b). Observed DDT levels may be high enough to affect reproduction of fishes and invertebrates in lower Laguna Madre and may have contributed to low blue crab numbers (Bryan 1971). Overall, water quality of Arroyo Colorado is poor, and a large portion of the waterway suffers from pollution-induced oxygen depletion (Bryan 1971).

Laguna Madre is a major hypersaline lagoon that is unique as a physical, chemical, and biological system (Bach and Cofer 1981). Lower Laguna Madre and its associated coastal bays, estuaries, and wetlands represent the largest contiguous habitat type in LRGV (USFWS 1986). Wind-blown tidal flats of Laguna Madre typically comprise the entire intertidal zone because the arid climate and low freshwater runoff prevent development of estuarine salt marshes (Pulich et al., in press). The area has an abbreviated food chain that goes from plant detritus to forage fishes and shrimp to top carnivores (Bach and Cofer 1981). Fish and shellfish harvests are important to the local economy (Perez 1986).

Pesticides that are carried in irrigation water to Arroyo Colorado flow through Laguna Atascosa NWR into Laguna Madre estuary. Pesticide contamination is therefore magnified in Lower Laguna Madre, and increases in pesticides could cause mortality, reproductive failure, or physiological disturbances in local animal and plant populations (Bach and Cofer 1981). In a survey of Texas bays, Lower Laguna Madre oysters (*Crassostrea virginica*) had higher pesticide levels (e.g., up to 0.583 ppm DDT, 0.17 ppm DDE, 0.52 ppm DDD, 0.046 ppm dieldrin, and 0.032 ppm endrin) than oysters from other areas; the associated watershed had the highest rate of pesticide application/ha of cropland in LRGV (Childress 1965, 1966, 1967, 1968). DDT residue in fish tissue reached 7.2–8.1 ppm (Childress 1967, 1968). Elevated concentrations of DDE and toxaphene also have been found in a fish and migratory birds in the Lower Laguna Madre (USFWS 1986).

Water project construction has and will result in increased levels of silt, nutrients, pesticides, and turbidity entering Laguna Madre. Negative impacts from herbicides include reduced oxygen, increased carbon dioxide, lower pH, increased bacterial populations, change in nutrient status of water, and changes in plant and animal communities. Most herbicides cause serious declines of both fauna and flora over a short period (Newbold 1975). Herbicides from agricultural drainwater inflows and decreased light levels associated with turbid water have an adverse impact on seagrass (submergent marine flowering plants) production. Seagrass functions in carbon fixation, sediment stabilization, nutrient cycling, as a critical food resource for redheads (*Aythya americana*) and other wintering waterfowl, (P. J. Zwank, personal communication), and as nursery and rearing areas for fish and shellfish (Perez 1986; USFWS 1986). Elimination of seagrass could increase erosion and reduce associated biota that use seagrass for food, shelter, and reproduction (Bach and Cofer 1981).

Conclusion

Construction of irrigation and floodway systems destroys native brush, degrades water quality, and facilitates transport of pesticide-laden sediments throughout LRGV. Reduced river flow results in many detrimental effects on native plants and wildlife. Other values lost by damming and diverting rivers and using water in flowing streams include aesthetic, recreational, scientific, and environmental quality (Hamilton 1971). According to Ramirez (1986), additional river impoundments on the lower Rio Grande should be avoided and less damaging alternatives (e.g., water conservation and desalinization) to solve water problems in LRGV should be encouraged. To prevent further degradation of the Rio Grande, Judd (1985a) suggested use of legislation to preclude construction of new dams or floodways, and establishment of incentives for municipal, industrial, and agricultural users to conserve water.

Historical and present water developments in LRGV have affected negatively the Matamoran District Tamaulipan brushland ecosystem. Proposed developments may involve even more severe impacts because of the already reduced natural habitat, its isolation in corridors and small tracts, and the seriously perturbed hydrological system of LRGV.

Brush Eradication

Preservation and enhancement of existing brushland in LRGV, restoration of previously cleared and disturbed areas, and acquisition of additional acreages are primary management concerns of the USFWS. Estimates of remaining native brush range from 1% to 5% of original vegetation, so protection of remnant brush tracts is imperative. There are now Federal and State agencies and conservation groups that concur with the goals of the USFWS, but that has not always been the case. Since the early 1900's, a prevalent local philosophy among developers and ranchers in LRGV has been that native brush was worthless and should be eradicated (Gilbertson 1988).

Past and Present Approaches to Brush Clearing

Mechanical. In the early 1900's, land managers began large-scale removal of brush (Inglis et al. 1986). In a brush removal survey, Davis and Spicer (1965) classified 89% of the Rio Grande Plain as rangelands where forage production depended on native plants or introduced perennials that did not require repeated cultivation. Of that, 28% had experienced some brush eradication in the past 30 yr. In the late 1920's, individual shrubs and trees were killed with kerosene (Inglis et al. 1986). Extensive mechanized brush removal began in the early 1930's and developed through phases of large tractors pulling steel cables, heavy anchor chains, large rolling choppers, root plows, brush mowers, and tree grubbers (Inglis 1964; Inglis et al. 1986).

Until 1955, extensive areas of brush were destroyed by chaining or chopping. From 1956 to 1960, root-plowing and seeding of small blocks of rangelands comprised about 25% of all brush removal (Davis and Spicer 1965). Throughout the Rio Grande Plain, about 3,240 ha (8,000 acres) of brush/year were destroyed from 1930 to 1948; about 21,460 ha/year (53,000 acres/year) were destroyed from 1949 to 1954; and about 19,430 ha/year (47,992 acres/year) were destroyed from 1955 to 1959 (Davis and Spicer 1965).

Up to the early 1970's, most brush removal in south Texas was done mechanically with heavy equipment. During that time, energy was relatively inexpensive, and herbicides did not effectively eradicate many of the species in the mixed brush complex (Mutz et al. 1978). From 1940 to 1981, Texas landowners treated an average 600,000 ha (1,482,000 acres) annually to remove thorn forest (Welch 1982). Most brush management efforts led to a control-regrowth cycle of 5–10 yr (Davis and Spicer 1965).

Chemical. Until the late 1940's and early 1950's, most herbicide application attempted to target individual plants, but available herbicides were not selective (Scifres 1977). In the early 1960's, chemical growth stimulants and poisons were used to destroy brush (Inglis et al. 1986). In the early 1970's, herbicides that could destroy many of the common woody species in Texan mixed brush communities were developed (Beasom and Scifres 1977; Mutz et al. 1978). The phenoxy herbicide 2,4,5–T destroyed honey mesquite, but it released herbicide-tolerant species. New herbicides, such as dicamba, destroyed most species. When picloram became commercially available, it was combined with 2,4,5–T for brush spraying in south Texas. Tebuthiuron is a new compound that destroys some herbicide-resistant woody species (Mutz et al. 1978). Recovery is inhibited for at least 8 yr post-treatment (Rappole et al. 1986). Nevertheless, chemicals are still not selective enough to prevent damage to non-target species (Teer, in press).

Aerial spraying with selected herbicides takes about a month to reduce brush cover (Beasom et al. 1982; Scifres 1980b). Aerial spraying of liquid herbicides proved to be damaging to adjacent susceptible crops (Bontrager et al. 1979; Mutz et al. 1979). Pelleted herbicides can reduce drift to nontarget areas, essentially eliminate volatility hazards, extend the period for effective herbicide application, and can be applied with ground or aerial equipment (Mutz et al. 1979); however, surface runoff and thus damage to adjacent areas remains a problem.

Fire. Naturally occurring wildfires are not common in LRGV. Most of the vegetative associations now present are not fire dependent, but shrubs in LRGV exhibit fire-tolerant adaptations. On Welder Wildlife Refuge (Sinton, TX), 95% of the upland shrubs sprout from the root crown when the top is removed by fire; other species such as live oak can root sprout and form large colonies (Hanselka 1980). None of the 95 fires in Santa Ana and LRGV NWRs reported to date began in or penetrated into what is considered "climax" Tamaulipan brushland (N. M Gilbertson, personal communication).

Detrimental Effects to Fauna and Flora

Mechanized brush removal methods can be categorized in two broad groups based on type of action on woody plants. The first method is designed to simply remove above ground growth and includes roller chopping and shredding. Top removal kills woody species that are incapable of resprouting from basal stem segments, roots, or rhizomes (Mutz et al. 1978). The second brush removal method involves destruction of the entire woody plant by grubbing, chaining, or root plowing (Mutz et al. 1978).

The most drastic reductions in brush cover are achieved with methods that disturb soil and remove roots of brush plants (Drawe 1977). These methods have particularly adverse effects on fossorial species (e.g., Texas tortoise). Removal of brush results in loss of shade cover, physical damage, and rough terrain with deep furrows and mounds (Rose and Judd 1982). Root plowing causes maximum surface soil disturbance and usually results in comparatively long-term (ca. 20 yr) brush suppression. It also eliminates brush cover and seriously reduces browse availability for an extended period (Mutz et al. 1978). Reduced browse has a negative impact on white-tailed deer and other species that depend on woody plants for forage and cover (Guthery 1980; Fulbright and Beasom 1987). In the early stages of conversion from thornscrub to grass, mechanical brush clearing causes greater initial reductions in lizard and small mammal populations than selective herbicides. Large areas that are completely and permanently cleared have significant wildlife losses (Lillywhite 1977).

Grass production benefits from brush reduction are short-lived and seem to be largely the result of release of nutrients from the dead brush stems and roots (Gilbert, in press). Retreatment is necessary within 15 yr after root-plowing and within 2 yr after chaining (Rappole et al. 1986). Additionally, detrimental effects of brush control practices may last longer than temporary benefits gained for livestock production. Density of mesquite was 3–4 times greater in root plowed areas 25 yr after treatment than in untreated areas (Fulbright and Beasom 1987).

Community species richness is much lower in treated than untreated brushland; many plant species that are valuable to wildlife are rare or absent (Fulbright and Beasom 1987). Recent studies of succession in Texas brushlands (Bush and Van Auken 1986a,b, 1987; Van Auken and Bush 1985; Van Auken et al. 1985) have shown that brush species change soil quality during succession and that both edaphic and light requirements affect species order during successional stages. Brush acts as a soil enhancer, especially for nitrogen, which is often limiting in arid soils (Gilbert, in press). Altering succession to graminoid stages thus reduces productivity of the entire community.

Treatment by spraying causes less initial physical disturbance than mechanical clearing (Beasom and Scifres 1977; Inglis et al. 1986). Nevertheless, in a mature honey mesquite brushland that was completely sprayed with 2,4,5–T + picloram (1:1), populations of white-tailed deer, wild turkeys, and feral hogs were reduced; collared peccary were reduced because of reduction of prickly pear cactus, their major food (Beasom and Scifres 1977). Chamrad et al. (1979) found that herbicide use was initially detrimental to forbs and thus temporarily lowered habitat quality for deer. Clearing shrubs by spraying with 2,4,5–T or cutting can result in a 30% reduction in number of bird territories by the following spring (Slagsvold 1977).

Relatively cool fires (i.e., maintenance burns) applied within 2–4 yr after mechanical top removal usually destroy woody resprouts and invading seedlings (Mutz et al. 1978). Fall burning of shrubs significantly reduces brush canopy in both untreated areas and areas treated by roller chopping, shredding, or scalping (Box et al. 1967). Huisache is an important species in the mixed brush (i.e., *Prosopis-Acacia*) complex of south Texas (Bontrager et al. 1979) that is used by wildlife for browse, mast, and cover (Scrifes et al. 1982a). Exposure of huisache to fire usually killed canopies of > 90% of the plants; however, all burned huisache plants sprouted after treatment, regardless of season or intensity of burning (Rasmussen et al. 1983).

In areas of extensive farmland where wild plant cover is scarce, burning reduces wildlife use (Guthery and Stormer 1984). Loss of protective cover by fire may increase raptor predation on small mammals (Tewes 1984). Following prescribed fire, it may take 2–3 yr to return to pre-burn species composition and density (Drawe 1980). Fire is not used as a management tool in LRGV, and until there is evidence that fire is needed, it is not a necessary tool for enhancement or maintenance of the present system. Fire in other areas tends to favor grasses over woody vegetation, an undesired outcome in LRGV.

Brush Management for Native Flora and Fauna. General prescriptions exist for brush reduction and removal (U.S. Department of Agriculture [USDA] 1970; Scifres 1980a); however, native flora and fauna will benefit most when brush eradication programs are eliminated in LRGV. Brush should always be left along drainages, on steep slopes, near watering and roosting places, and on other areas that are most attractive to wildlife in LRGV. Other preferred wildlife areas such as along rivers, creeks, resacas, and playas also should not be perturbed with mechanical brush removal, herbicides or fire.

Introduced Grasses. Buffelgrass (*Cenchrus ciliaris*) is an introduced grass that has spread to thousands of hectares in south Texas. This highly competitive plant spreads into native plant communities, but it is of little value to wildlife. Monocultures are prone to die-offs during cold spells, and buffelgrass provides few nutrients during drought (Rappole et al. 1986). Widespread clearing to plant buffelgrass pastures destroys ocelot habitat (Tewes and Everett 1982). Populations of reticulate collared lizard are reduced by land clearing practices, conversion of native grazing lands to farms and improved pastures, and spread of buffelgrass (Judd 1985a). Buffelgrass presently is invading the only known population of endangered ashy dogweed. Dense stands of this exotic grass prevent survival of most other plant species, including the endangered Johnston's frankenia (Editor 1987). Additionally, densities of cotton rats (*Sigmodon hispidus*) were four times greater on areas planted to exotic grasses than on native rangeland (Guthery et al. 1979), which likely decreased endemic populations of small mammals. Native flora and fauna would benefit from the eradication of buffelgrass and other exotic plant species from LRGV.

Urbanization

Along with water projects and agricultural development, urbanization is a threat to the unique flora and fauna of LRGV. Human population in the area has increased steadily since the early 1900's (Figure 9). A 40% region-wide population growth from 1980 to 1990 is projected, compared to the State average of 27% (TPWD 1985). Census figures from 1982 show a population of 230,500 in Cameron County. Brownsville, the county seat, is the largest city (84,997). Hidalgo County had a 1982 population of 315,000. McAllen

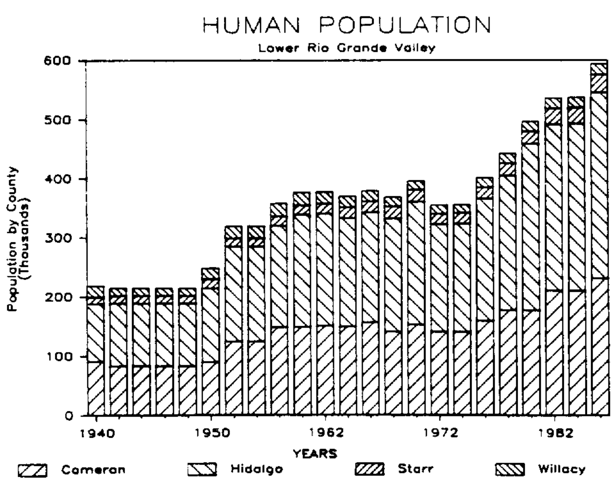

Figure 9. Human population size by county in the Lower Rio Grande Valley, 1940–86.

(66,281) is the largest city in the county, and Edinburg (24,075) is the county seat. The population of Starr County was 30,000 in 1982, and Rio Grande City (5,720), the county seat, is the largest city. Willacy County had the smallest (18,200) 1982 population in LRGV; the county seat and largest city is Raymondville (9,493) (Dallas Morning News 1986/87).

Brush Clearing

Clearing of native brush is the primary effect associated with urbanization. For example, waterfront housing subdivisions have been built on many resacas near Brownsville, which has resulted in loss of unique native riparian woodlands and critical wildlife habitats (Ramirez 1986).

Sewage

An additional impact associated with urbanization is dumping of untreated municipal sewage into the Rio Grande from Mexico and possibly some U.S. cities (USFWS 1986). Quantitative data on effects of untreated sewage on associated faunal and floral species in the Rio Grande are not available; however, degradation of water quality is likely. Sewage dumping contributes to eutrophication of waterways because nutrient levels in the water, especially nitrogen and phosphorus, increase. These nutrients enhance algal production, which results in increased turbidity. Rooted macrophytes may become shaded and eventually killed if growths of epiphytic algae are excessive (Liddle and Scorgie 1980). Loss of macrophytes results in a loss of fauna dependent on them; for example, waterfowl.

Specific responses of wetland ecosystems to sewage disposal are difficult to predict (Guntenspergen and Stearns 1985). Wastewater disposal can result in the addition of nutrients, suspended and dissolved solids, chlorine, heavy metals, and disease organisms to wetland systems (Brennan 1985). Inadequate treatment may cause reduced dissolved oxygen levels and increased presence of toxic substances, which can result in fish kills, decreased species richness, and increased occurrence of diseases (U.S. Environmental Protection Agency [USEPA] 1983). Changes in flow rate and periodicity, water levels, and vegetation structure and composition as a result of sewage inputs likely cause a wide range of changes in invertebrates, fish, amphibians, reptiles, birds, and mammals that depend on wetland areas (USEPA 1983; Brennan 1985).

Effects of sewage wastewater disposal in wetlands are not available for LRGV, but they have been investigated elsewhere. Wetlands that receive large amounts of agricultural and industrial waste are most likely to contain pathogens transmissible to wildlife (Friend 1982). Additionally, chemicals from sewage effluent that reach wetlands are health concerns (Friend 1982). Outbreaks of *Clostridium botulinum* type C frequently occur in California wetlands and occasionally elsewhere in the United States (Friend 1982). Wastes from domestic sources are less likely to contain wildlife pathogens if they have received at least secondary treatment. Migratory waterfowl and shorebirds are at greatest risk from sewage effluent discharges in wetlands because they are attracted in large numbers to sites that could be contaminated (Friend 1982).

Road Construction

Road building is positively correlated with human population growth. The number of roads, and brushlands lost to road construction, increases each year in south Texas and northeastern Mexico. On the United States side of the border, communities form an almost continuous chain of urban development along U.S. Highway 83, which parallels the Rio Grande within a 5- to 13-km (3- to 8-mi) belt. A network of State, farm-to-market, and county roads interconnect communities with farm and orchard lands (IBWC 1973). Roads are particularly abundant in Hidalgo and Cameron Counties, where there is a paved road virtually every 1.6 km (1.0 mi) (Judd 1985a).

Roads have direct and indirect impacts on wildlife. Road building can result in drainage of ponds and low areas that temporarily hold water, thus altering the hydrology of an area (Van der Zande et al. 1980). Vehicle traffic kills a large number of wildlife each year; populations of black-spotted newt (*Notophthalmus meridionalis*) may be reduced due to traffic mortality (Judd 1985a). The ocelot population in LRGV is significantly affected by road mortality (M. E. Tewes, personal communication). Demand for caliche, which is used locally in road construction, also threatens critical habitats of some species such as the reticulate collared lizard. Road construction isolates parts of habitat and can affect artificially disjunct animal communities by interfering with natural exchange of dispersing animals (Van der Zande et al. 1980; Mader 1984). Other disturbances associated with roads include noise, dust, headlight illuminations, and lead, cadmium, and sulfur dioxide emissions from automobile exhaust (Mader 1984).

Industry

A wide variety of businesses, mostly light industries, exist in the LRGV (Dallas Morning News 1986/87). Cameron County businesses include fruit, vegetable, and seafood processing; fishing; shipping; tourism; agribusiness; manufacturing; and natural gas and oil production. Businesses in Hidalgo County include food processing, shipping, other agribusinesses, tourism, and mineral operations. Mineral production includes oil, gas, sand, gravel, and stone. Businesses found in Starr County are vegetable packing, shipping, other agribusinesses, oil processing, and tourism. Oil, gas, sand, and gravel production also occur in this county. Mineral production, agribusiness, tourism, and shipping occur in Willacy County. Mineral production centers on oil and gas (Dallas Morning News 1986/87).

A variety of industries in the LRGV discharge wastes into the Rio Grande and into Sal Vieja and Arroyo Colorado drainage canals. The combination of contaminant sources is potentially detrimental to all associated refuge habitats (USFWS 1986). In absence of floods, industrial runoff contributes to contamination and siltation in resacas. As of 1981, stormwater runoff from urban areas was not a significant nonpoint source pollution problem (Black and Veatch Consulting Engineers 1981a). However, more recent studies indicate that runoff degrades water quality in resacas as a nonpoint source for fecal coliform bacteria, oil and grease, chlorides, phosphates, and nitrates (Ramirez 1986). Higher PCB residues found in Texas aquatic bird eggs were consistently associated with industrial and urban areas (King et al. 1978).

Recreation

General

Mild climate in LRGV in conducive to outdoor activities during all seasons and attracts many winter tourists (Fleetwood 1973). The area also is important as a gateway to Mexico (Dallas Morning News 1986/87). In 1975, the winter visitor population in Cameron, Hidalgo, and Willacy counties was 126,151 (IBWC 1982b). More recently, more than 500,000 visitors from northern states arrive each year to winter in LRGV (Schumacher et al. 1988). The yearly influx of winter visitors results in economic benefits to LRGV but can result in heavy use of existing recreation resources (TPWD 1985).

The three National Wildlife Refuges, several state parks, and private sanctuaries in LRGV serve as greenbelts and open spaces – locations for passive activities, preservation areas for unique natural features, and interpretive sites that highlight or explain ecosystem processes (TPWD 1985). Santa Ana NWR (Figure 10), Laguna Atascosa NWR, and Bentsen–Rio Grande State Park attract about 300,000 visitors annually. Falcon Reservoir also provides many recreational opportunities. Total visitation to the 4 counties generates nearly $500 million/yr for the local economy (USFWS 1988).

Visitors who are interested in the natural resources of LRGV generally go to refuges or parks that have visitor centers, established trails, picnic areas, campgrounds, or other public facilities (Figure 2). Visitors can have a direct impact on undisturbed brush when their activities are uncontrolled. However, private development associated with recreation, especially along the Rio Grande, has even more serious impacts. Private RV parks adjacent to the river include boat

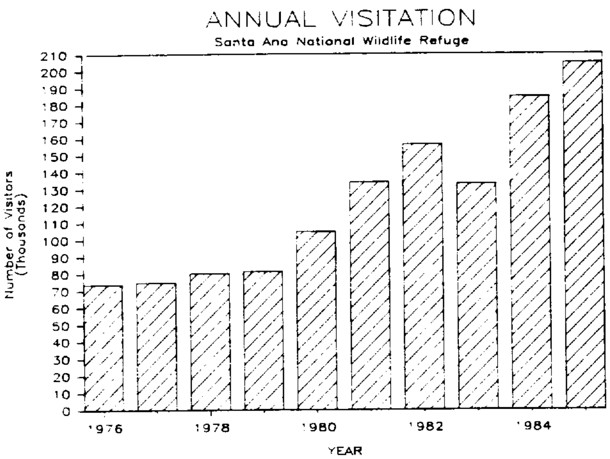

Figure 10. Annual visitation to Santa Ana National Wildlife Refuge, 1976–85.

ramps, docking facilities, and vehicle sites; such development requires clearing of riparian brush. Intensive recreational activity and disruption of the riparian corridor anywhere along the Rio Grande is detrimental to wildlife, especially endangered felids (Ramirez 1986).

Boating

Negative impacts caused by boating include: turbulence, turbidity, cutting of vegetation by propellers, direct contact with river banks and riparian vegetation, visual and auditory disturbance to animals, pollution from motors, and sewage. Shore-based recreation such as fishing and swimming results in trampling of vegetation, erosion, sewage, and other chemical impacts (Liddle and Scorgie 1980). Human disturbance also affects nesting success of birds by causing inter- and intraspecific behavioral imbalances. Brown pelican and Heermann's gull (*Larus heermanni*) colonies in California have been damaged significantly by recreationists (Anderson and Keith 1980).

Fishing and Hunting

Freshwater and saltwater fishing and hunting are major consumptive recreational activities in LRGV (USFWS 1983). Hunting alone is a multi-million dollar "industry." White-winged doves (Figure 6) and white-tailed deer are the most important game species; others include collared peccary, northern bobwhite (*Colinus virginianus*), mourning dove, scaled quail (*Callipepla squamata*), and plain chachalaca (Collins 1984).

Game species can be managed as a sustained yield for profit and recreation (Kiel 1980). Access to wildlife for hunting purposes is controlled by most Texas landowners under a lease system whereby the hunter pays a certain fee/ha for the lease or per animal shot (Rappole et al. 1986). Each year, more than 15,000 landowners in Texas make lands available for hunting on a fee basis (USDA 1970). In agricultural areas, economic return from a hunting lease program may exceed any potential increased production from land clearing activities (Collins 1984). Economic value of hunting leases equals or exceeds net income from livestock production on many ranches; such financial incentives should stimulate preservation of high quality wildlife habitat (USDA 1970).

Rangeland that is managed to produce both wildlife and livestock can net the landowner \$10–\$15/ha (\$4–\$6/acre) or more annually through lease hunting in addition to income from livestock production (Kiel 1980). If a deer herd is properly managed and harvested, quail and dove hunting also can be profitable on the same land (USDA 1970). Although collared peccary hunting is not popular with Texas hunters, out-of-state hunters pay \$50–\$200/head (Carl and Brown 1980).

As income from leases to hunt white-tailed deer has increased in south Texas, ranchers have come to appreciate the value of managing their lands for both cattle and deer (Meyer et al. 1984). Woody cover provides shaded bedding areas for deer, cattle, and collared peccaries (Drawe and Higginbotham 1980). Bobwhites use low, densely branched clumps of woody vegetation for loafing cover (Lehmann 1974). Diverse vegetation, particularly of herbaceous species, may be best in the long run for cattle (Kiel 1980).

White-winged dove hunting generates \$20 million annually for the local economy in LRGV (USFWS 1983). Habitat acquisition for white-winged doves was a low priority for Texas until 1971, when the legislature authorized the sale of dove stamps. Revenue from stamps can only be spent for white-winged dove research and management, and acquisition, lease, or development of habitat. Stamp sales generate more than \$250,000 annually (George 1985). Previously, excessive hunting pressure occurred on specific segments of the white-winged dove population when areas were open to hunting for consecutive seasons. Establishment of six small sanctuaries along the Rio Grande (rather than two large ones) that are open on alternate years now distributes hunting pressure more evenly. This system ensures some protection of white-winged doves and provides optimum hunter and landowner opportunity (Dunks 1978).

Demand for waterfowl hunting in LRGV is not as great as for other types of hunting, but in a survey of bird use of wetlands in the middle Rio Grande Valley, Chaney (1981) found heavy hunting pressure in several areas. Additionally, the recent establishment of two Ducks Unlimited chapters in LRGV has lead to increased demand for waterfowl hunting opportunities. Ponds are important stopover sites for migrating birds and spring and summer nesting areas for many species. Laguna Atacosa NWR is a primary wintering area for redheads (USFWS 1986), and South Bay, part of the

Lower Rio Grande Valley NWR, is also important. Draining and filling of many potholes and wetland areas has resulted in reduced waterfowl habitat in LRGV.

Because of the money generated by white-winged dove stamps for habitat preservation and because management practices favoring wildlife have been adopted by some Texas landowners, hunting has provided impetus for conservation of native brush and associated wildlife. These activities probably will provide increased incentive for management practices that benefit native flora and fauna.

Current Management: An Evaluation

Numerous human activities threaten native brushland in LRGV and make protection of remnant brushland tracts imperative. The USFWS uses several protection methods, including land purchase, easement, and land lease to acquire management rights to these tracts (USFWS 1980, 1983, 1985). In some areas where Tamaulipan brushland has been cleared completely for cropland, Federal and State agencies, and private conservation organizations have developed methods to restore brush species. Investigations continue on ways to increase cost-effectiveness and survival of restored vegetation.

Land Purchase

Fee acquisition of lands in LRGV by USFWS results in preservation of riparian and upland brushland habitat and associated wildlife. Soil conservation, brushland, and water quality improve after acquisition. The local county receives refuge revenue sharing funds for any lands acquired in fee by USFWS (USFWS 1983). Land purchase offers a permanent conservation alternative and affords the most unrestricted management option to USFWS.

Easement

When properly designed, conservation easements can be a valuable and viable preservation initiative in LRGV, but primary resource protection must be accomplished. Easements may have potential to aid establishment of a wildlife corridor along the Rio Grande floodplain by protecting those key tracts where the present owners cannot or will not sell or transfer full rights. Perpetual easements meet objectives best when they assure future preservation of brushland habitat. Typical easements grant USFWS wildlife management rights on the property with the owner retaining all other uses. Easements in LRGV therefore must be tailored to the individual tract of land. Easement terms must be variable between biotic communities and can approach full initial cost of fee acquisition. The USFWS must have the right to fence and post easement areas and prohibit clearing of brushland or uses that would impact wildlife habitat, for example, overgrazing and excessive public use (USFWS 1983).

Land Lease and Land Management Agreements

Use of mutually-beneficial, no-cost leases and agreements, especially on brushland owned by public entities, is a viable conservation tool. For example, the Brownsville Navigation District has leased 1,873 ha (4,627 acres) to USFWS for 40 yr at no cost as mitigation (USFWS 1983). Leases of property for a specified number of years have been used by USFWS on several refuges when critical habitat preservation needs must be met.

These options do not give as much freedom in management programs as fee title or easement. Costs associated with preparation of appraisal reports and other overhead are the same as in a fee or easement. A second problem with leases is that Federal procurement regulations proscribe payment for leases until wildlife management rights are actually received by the government. Leasing may result in future uncertainty to landowners and USFWS because either party may terminate the agreement at the end of any lease period (USFWS 1980).

Restoration of Cropland

Native brush has been reduced so severely that a key to preserving wildlife in LRGV is restoration of habitat through reforestation (Miller 1985b). For this reason, remnants of farms and pasture land are often included in purchases of natural areas (Gilbertson et al., in press).

Habitat restoration research began in the late 1950's on the Longoria Unit of Las Palomas WMA (TPWD). Five important woody species were used in this research: Texas ebony, anacua, huisache, granjeno, and brazil. Seedlings were dug by hand from existing native brush stands and transplanted into cultivated test plots (George 1985). Maximum area planted was 2.5 ha/d (6.2 acres/d) (Miller 1985b). Restoration of native brush was feasible with these methods, but because of the extensive amount of hand labor involved, it was very costly ($2,500/ha [$1,012/acre]). White-winged doves nested in revegetated ares within 3 yr, and nesting densities reached 100 pairs/ha (40 pairs/acre) 25 yr post-planting (George 1985). Under favorable conditions, white- winged doves can nest in huisache 18 mo after planting (USFWS 1978).

With current technology, revegetation can be made less labor-intensive. Seeds can be germinated and reared in a greenhouse and later planted at a restoration site with a chisel-type planter pulled by a 4-wheel driven drive tractor (George 1985; Miller 1985b). The combination of mechanized planting and greenhouse seedlings makes revegetation of cropland to native brushland economically feasible ($400/ha [$162/acre]). Under some agreements, farmers care for revegetated fields and plant food crops for doves on other cleared land nearby (Miller 1985b). About 25 ha (62 acres) of native brush were planted in LRGV in 1984, 300 ha (741 acres) in 1985, 350 ha (865 acres) in 1986, 520 ha (1,285 acres) in 1987, and 600 ha (1,482 acres) will be planted in 1988 for a total of 1,795 ha (4,435 acres) (N. M. Gilbertson, personal communication). Current studies involving use of plant-growth hormones (i.e., gibberellic acid) and light-control devices indicate that brush restoration may be even more cost effective in the future (George 1985).

As part of revegetation research, several studies have been conducted on seed germination requirements of woody species. Texas ebony germination is usually low because of the hard seed coat. Soaking seeds in H_2SO_4 for scarification increased germination of Texas ebony seeds (Alaniz and Everitt 1978). Salts apparently have little effect on seed germination and seedling growth. Emergence was optimal when seeds were planted 1 cm (0.4 inch) deep (Alaniz and Everitt 1978). Germination of huisache seeds also is constrained by a seed coat that appears to be impervious to water; however, after the seed coat is broken, germination occurs rapidly (Scifres et al. 1982a).

Anacua germination also is restricted by an impermeable seed coat (Alaniz and Everitt 1988). Germination was not enhanced by chemical scarification or rinsing with water. Gibberellic acid increased germination from 35% to 61%. Mechanical scarification and dry heat only enhanced germination of highly dormant seeds (Fulbright et al. 1986). Emergence is optimal when seeds are exposed on the soil surface (Alaniz and Everitt 1988).

Many woody species in LRGV produce few seeds at irregular intervals. Asexual propagation methods need to be developed for these species. Seeds are not easy to obtain from species such as brush holly (*Xylosma flexuosa*) and devil's claw (*Pisonia aculeata*); however, these species are easily propagated by stem cuttings. No root promoting substances are necessary. In fact, results showed decreased rooting success when synthetic root-promoting substances or nutrient solution were used (Heep and Vora 1986).

More basic research is needed on native species of trees, shrubs and grasses that provide habitat and food for wildlife in LRGV. Little is known about riparian communities along the Rio Grande, and cedar elm and baretta communities are especially in need of study. The arboretum at Santa Ana NWR should be expanded to serve as a source area for nursery stocks of native plant species in LRGV. Although revegetation projects are important, preservation of existing habitat is preferable and less expensive than acquisition and restoration of cleared land (George 1985).

Constraints

Land Title Problems

Spanish land grants in the floodplain of the Rio Grande date back to the early 1500's (USFWS 1983). When Hispanic settlements became part of the United States territory, Spanish land grants were respected and private ownership was affirmed by the new government. Land grants were generally large acreages, and the tendency for large ranches continues to the present (Crosswhite 1980).

Ownership of much of the lands designated as Falcon Woodland (Figure 6), approximately 9,700 ha (24,000 acres) in LRGV, requires curative title actions to clear long-standing land claims (USFWS 1985). In this area, title problems have discouraged USFWS from purchasing lands. Meanwhile, this brushland continues to be converted into cropland, pasturelands, or homes and recreational outlets. This conversion has a negative impact on ecological integrity in the area and adds curative costs to acquisition and management plans. Habitat must be protected until some means can be found to provide permanent protection (R. W. Schumacher et al., in press).

Habitat Fragmentation

Many remnant brush tracts in LRGV are small (< 40 ha [< 100 acres]) and scattered (USFWS 1983). Isolated native brush tracts in extensively cleared areas may serve as "islands" of wildlife habitat (Blake and Karr 1984). The size of natural areas, or the degree of fragmentation, and their proximity to each other influence recruitment and extinction relationships (Diamond 1975). Larger areas, or small areas with close neighbors, provide increased diversity, dispersal potential, and lower extinction rates (Harris 1984).

On an island, population size and probability of extinction for a species are greatly affected by body size, trophic level, and habitat specialization (Brown 1971). On montane islands, small mammals are found on more islands than large mammals, herbivores more than carnivores, and herbivores that are generalists inhabit more islands than herbivores that are specialists. Species that occur on only a few montane islands usually are found only on large islands. In cases where environmental changes (e.g., the result of human activity) have caused massive extinctions, numbers of species on an island will be less than the equilibrium number (Brown 1971). Such relationships may be operative in LRGV, and their potential effects are incorporated into the resource protection and management strategy for LRGV.

Island Biogeography

The theory of island biogeography includes ideas such as: the number of species on an island is positively related to its area; when immigration and extinction rates are equal, the area will reach a biotic equilibrium; and island area is correlated with environmental diversity, which has a more direct effect on species number than area alone (MacArthur and Wilson 1967). This theory has stimulated much theoretical and empirical discussion.

The theory of island biogeography has been extended to include continental areas. A biological island is an area of at least marginal habitat surrounded by areas of unacceptable quality (Picton 1979; Picton and Mackie 1980). Most nature reserves are natural landscape "islands" surrounded by expanses of culturally modified habitat (Pickett and Thompson 1978). Direct or indirect human influence is the greatest threat to preservation goals of nature reserves (White and Bratton 1980). A major effect of human perturbations such as agriculture, roads, and grazing has been habitat fragmentation (Middleton and Merriam 1985). Probability of extinction may be high if available habitat in and around the area has decreased because of habitat destruction and disturbance (Soule and Simberloff 1986). Such disturbance and its associated habitat fragmentation are prevalent in the LRGV, but local extinction rates are unknown.

Effect of Size

The relative merits of one large versus several small refuges in maintaining species richness have been debated in the ecological literature. Diamond (1975) believed that large reserves that are close to other reserves contained more species than small, isolated reserves because of the higher extinction rate in small reserves. However, archipelagos of small islands may have more plant species among them than a single large island of equal area (Simberloff and Gotelli 1984). Several reserves with occasional inter-reserve migration may be the optimum design strategy for genetic conservation (Boecklen 1986). On the other hand, large reserves likely are needed to maintain ecological processes, with additional reserves necessary for perpetuation of particular endangered species (Kushlan 1979).

Although some argue that the theory of island biogeography is unsubstantiated (Margules et al. 1982; Reed 1983), many studies indicate that size, alone or with other factors, influences number of species found in an area and ecological health (Moore and Hooper 1975; Kitchener et al. 1982; Blake and Karr 1984; Opdam et al. 1985; Soule and Simberloff 1986). There is substantial evidence that the probability of loss of rare species is related to reserve size and isolation, species natural history, and population size and isolation (White and Bratton 1980). Habitat diversity, in combination with size, has a significant effect on species richness (Picton 1979; Kitchener et al. 1982; Reed 1983; Freemark and Merriam 1986). Additionally, reserve shape determines effective protection and management (Schonewald-Cox and Bayless 1986). Generally, nature reserves should be as large and numerous as possible (Soule and Simberloff 1986).

Current models may be insufficient to determine minimum area requirements of species. To achieve accurate area specifications, detailed natural history observations are necessary (McCoy 1983). Predictions of the equilibrium model are useless without autecological information on target species to be preserved (McCoy 1982; Boecklen and Gotelli 1984). Unfortunately, such information is lacking for most species in LRGV.

Effect of Isolation

There is evidence that isolated reserves may experience species depletion due to isolation from contiguous gene pools in surrounding natural habitat (Miller and Harris 1977). Lack of recolonization sources leads to decreased immigration, followed by increased extinction (Pickett and Thompson 1978; Wilson and Johns 1982). Agricultural activities cause habitat isolation and interfere with natural exchange of individuals via emigration or immigration (Mader 1984).

Isolation of reserves may result in ecosystem degradation (Kushlan 1979). In Maryland, forest isolation and plant diversity were the best predictors of local abundance of individual bird species. Red-eyed vireo (*Vireo olivaceus*) and wood thrush (*Hylocichla mustelina*) experienced declines of about 2% in local density with each 100 m (328 ft) of isolation (Lynch and Whigham 1984). Degree of isolation affects the number of bird species restricted to mature woods (Opdam et al. 1985).

The major reason for decline of tropical bird species in cleared forests in Mexico was isolation of forest remnants from larger tracts (Rappole and Morton 1985). Isolation and small size of remnants apparently made forest patches unsuitable for use by multispecies foraging flocks. Mature forests supported higher, more stable populations of forest-dwelling migrants and residents than disturbed forest, ecotones, and second growth sites (Rappole and Morton 1985).

Brushland tracts in LRGV are isolated. Movement rates and distances moved between tracts by various species in LRGV are unknown. Similarly, recolonization ability and optimum distances between brushland patches that would afford maximum species interchange are unknown. Considerable refuge research is directed toward clarifying these relations in LRGV.

Effects of Corridors

Use of corridors is becoming prevalent in reserve design (Noss 1987). The original landscape in many reserve areas, as in LRGV, was once a series of interconnected natural habitats. Thus, corridors are an attempt to maintain or restore natural landscape connectivity. Increased connectivity, along with increased effective habitat area, counteract habitat fragmentation (Noss 1987).

Corridors facilitate gene flow and dispersal of individual animals (Soule and Simberloff 1986). Life histories of wide-ranging animals suggest that maintenance or restoration of landscape connectivity is a good management strategy (Noss 1987). Corridors alleviate threats from inbreeding depression, and a network of refuges connected by corridors may allow persistence of species that need more resources than are found in one refuge. A corridor (e.g., riparian forests along the Rio Grande) is an important habitat in its own right (Simberloff and Cox 1987).

There may be costs associated with corridors, such as transmittal of contagious diseases or fire, and increased exposure of animals to predators, domestic animals, and poachers (Noss 1987; Simberloff and Cox 1987). However, potential disadvantages of corridors can be avoided by enlarging corridor width (Noss 1987). Because of probable human and associated disturbances, the best corridors are as wide as possible. Necessary width depends on habitat structure and quality within the corridor, the nature of surrounding habitat, human use patterns, and particular species that are expected to use it (Noss 1987). The ideal corridor width along the Rio Grande would be wide enough for target species to access sufficient food, water, and cover. In this way, genetic exchange could occur along the corridor, and populations could be maintained even though density at any particular place in the corridor might be low.

For the eastern chipmunk (*Tamias striatus*), fencerows were critical connections between woods separated by farmland. Minimum area for population survival was several woods and interconnecting fencerows. Small breeding populations were established in fencerows only 3-m (9.8-ft) wide (Henderson et al. 1985). On power-line corridors, bird density was correlated with corridor width, length of forest edge, and number of years after cutting of vegetation (Kroodsma 1982).

Application to the Lower Rio Grande Valley

Howe et al. (1986) investigated fragmentation of thornscrub habitats along the lower Rio Grande and its effect on local extinction or loss of numbers in populations of resident amphibians, reptiles, birds, and mammals. (Their survey only applied to the number of species present at a particular time. They did not address long-term persistence of species on these sites, nor did they examine reproductive success and survival.) Preliminary results did not demonstrate significant correlation between species abundance or frequency of occurrence of a selected group of species and tract size or shape, but larger mammals that require extensive tracts of undisturbed habitat were not addressed in the study. Total abundance of peripheral or rare species was significantly higher in the interior of large tracts than in small tracts. An isolated small strip had very low bird species richness, which suggested that distance from large tracts may be an important determinant of species richness (Howe et al. 1986). Vegetation density also may be an important component of faunal diversity and abundance. More small mammals were trapped in dense thorny vegetation in Laguna Atascosa NWR than in other habitat types (Scott 1982).

Rappole (1986) surveyed a 6.9 km^2 (2.6 mi^2) area of the Schalaben Tract (Figure 6) for ocelot and jaguarundi. The area was small, isolated, and degraded from overgrazing. No evidence of either species was found. If all of the habitat on the ranch were suitable for ocelots, it could support only 1–2 males and 3–4 females. Areas of this size may be too small to maintain viable populations of ocelots without the presence of neighboring thorn forest of similar or larger size. Normal fluctuations in population size due to drought or disease would likely cause complete elimination of small populations (4–5) in restricted and isolated habitats (Rappole 1986).

Tewes and Everett (1982) set the arbitrary minimum area for a unit of potential ocelot habitat as a contiguous dense brush stand of 40 ha (100 acres) or 2 proximate 30-ha (75-acre) tracts. Several small acreages of suitable brush were considered potential ocelot habitat if they totalled 40 ha (100 acres), were in close proximity (ca. 0.8 km [0.5 mi]), and if some type of brushy travel lanes were available. Nevertheless, home ranges were considerably larger than the minimum area suggested. A male ocelot had a 334-ha (825-acre) home range, and a female had a 269-ha (664-acre) home range. This highlights the importance of travel corridors between brushland tracts.

Resource Protection and Management Strategy of the LRGV Refuge Complex

The major issue facing the USFWS in LRGV is the continued loss of wildlife species, populations, and habitats in the Matamoran District of the Tamaulipan Biotic Province. The mission of USFWS is to preserve those species, populations, and habitats in perpetuity throughout the Matamoran District. Authority exists to identify and acquire important lands in the four southernmost counties of Texas that are critical to this mission.

The strategy applied to the resource protection efforts is dynamic in that it addresses both long-term and current needs of wildlife and its habitat. It also is pragmatic in that it recognizes that some opportunities to meet USFWS goals have only a narrow window in which action may be effectively initiated and that priorities often must change to meet current circumstances. Discussion in previous sections on various aspects of habitat alteration that affect all plant and animal populations have particular applicability to LRGV because isolation of habitats, fragmentation of remaining habitats, and needs of substantial numbers of species with low population numbers require special efforts to not only maintain populations but augment their numbers over time. Accordingly, USFWS has developed a five-part integrated approach to resource protection and management in the Matamoran District:

1. **Community Approach** – Because the project area is large and heterogeneous, communities under particular threat are given a high priority in acquisition and preservation planning. As additional communities become threatened by development, they will be included in this approach – hence the dynamic nature of the resource protection and management strategy.

2. **Corridor Approach** – The Matamoran District is essentially the riparian and deltaic reaches of the lower Rio Grande. The Rio Grande is the major corridor for movement of flora and fauna within the District because of the destruction of native habitats in surrounding areas. Most communities of concern to USFWS are within practical reach of the Rio Grande. Thus, this approach is intended to maintain and repair the riparian link between important biotic communities.

3. **Anchor Approach** – La Sal Vieja, Falcon Woodland, and the estuary of the Rio Grande are large enough to maintain in perpetuity most of the species now found within them. These units maintain the biological material needed to safeguard gene pools and replenish populations throughout the corridor. This approach recognizes the value of maintaining large units on the edges of the project area that augment the smaller units throughout LRGV.

4. **Management Unit Approach** – Management Units are strategically placed habitats that are sufficient in size to provide food, water, and cover for selected target populations. They are valuable as sites that can maintain numbers and genetic material during periods of stress including the development stages of LRGV resource protection and management efforts. They are valuable as "stepping stones" for movements of species throughout the Valley. Santa Ana, Santa Maria, and Anzalduas are examples of Management Units.

5. **Island Approach** – Some individual fragments or "islands" of habitat left largely untouched when the Rio Grande delta was cleared contain important wildlife values not found elsewhere in LRGV. Historic sites of white-winged dove nesting and wetlands used by black-spotted newts are examples. The Thompson Road and Goodfields tracts are examples of such "islands."

The integration of the five approaches above recognizes the equal value of intrinsic attributes and synergistic and complementary aspects of communities, corridors, anchors, management units, and islands. Daily management, long-range planning, and habitat acquisition and protection efforts of the LRGV Refuge Complex use the combination of these five approaches to guide their efforts. However, it is important to note that management in LRGV is evolving in response to new environmental threats and conflicts. Although unforeseen crises may require additional efforts and perhaps a redirection of strategy, for the present, a combination of the five approaches is the optimal means to meet LRGV resource protection and management needs (N. M. Fuller and R. W. Schumacher, personal communication).

Management Suggestions

Current and future management of Tamaulipan brushland in LRGV is a portion of the overall USFWS resource protection and management strategy. These efforts focus on two primary goals: acquisition and preservation of remaining native brush tracts, and acquisition and revegetation of previously altered brush habitats. Attainment of these goals will require cooperative effort between Federal and State agencies, conservation organizations, and private individuals. Public education and support are integral parts of achieving management goals.

We suggest the following management recommendations in support of current USFWS management efforts in LRGV. Not all of the following recommendations are novel, but in total they address a broad range of management alternatives that will enhance preservation of the unique and important Tamaulipan brushland of LRGV. These recommendations were synthesized from material reviewed for this report.

1. Acquire and preserve as many examples as possible of threatened biotic communities throughout LRGV. These reserves should be as large as possible.

2. Preserve remnants of the Rio Grande's deltaic forest.

3. Provide buffer zones to insulate refuges from detrimental effects of human activity.

4. Augment and encourage current international and conservation community interest in establishing a wildlife-wildland corridor on both sides of the Rio Grande between the levee system and the river.

5. Establish connecting corridors between the riparian corridor and isolated tracts near the river.

6. Make corridors as wide as possible to ensure that they encompass enough of each biotic community to guarantee preservation. Species such as large carnivores may require wide corridors to travel safely among reserves, but corridors facilitate dispersal and gene flow even if insufficient for residency.

7. Preserve as many secondary corridors on resacas, arroyos, canals, ditches, and other rights-of-way as possible.

8. Maintain and enhance cooperative conservation efforts of private, State, Federal, and international groups.

9. Use interpretation, extension, education, and individual contact to involve the LRGV community in resource protection.

10. Use public education to emphasize importance of brushland as wildlife habitat; educational efforts can help offset anti-environmental attitudes.

11. Encourage the public to fully understand the intrinsic value of the region's nature preserves.

12. If lands cannot be protected in other ways, propose to landowners that they manage their land as wildlife habitat for lease hunting, rather than clearing additional brushland.

13. Encourage users of agricultural chemicals to reevaluate current programs and to select the least ecologically damaging alternatives.

14. Determine feasibility of a settling basin system within conveyance canals to minimize input of additional sediment and contaminants into Lower Laguna Madre.

15. Plug old channels rapidly at the site of channel realignment to minimize impact of sedimentation on the downstream environment. This procedure will reduce the duration of contact between water and easily eroded, loose sediment used as backfill.

16. Substitute managed flooding for natural flooding to ensure preservation of riparian forests. Controlled floods should be scheduled during the summer and fall hurricane season to coincide with remaining natural cycles of vegetative growth and faunal reproduction.

17. Investigate potential use of misunderstood species of the region such as prickly pear and mesquite for forage, fodder, and even crop plants as a means to gain support for maintenance of natural vegetation.

18. Develop strong arguments for conservation of this unique habitat on its own merits, regardless of specific wildlife considerations.

Conclusions

The USFWS administers three National Wildlife Refuges in LRGV of south Texas. Each conserves dense Matamoran District Tamaulipan brushland, which is characteristic of the area under natural conditions. Current efforts to protect native brush include preservation of existing tracts owned by USFWS, acquisition of additional tracts, and restoration and revegetation of altered habitat. Other organizations that are deeply involved in preservation of Tamaulipan brushland include: Texas Parks and Wildlife Department; Frontera Audubon Society; Texas Organization for Endangered Species; Native Plant Project; Texas Nature Conservancy; Lonestar Chapter of the Sierra Club; The Valley Nature Center; the cities of Brownsville, McAllen, and Weslaco; Methodist Retreat; and the Boy Scouts and Girl Scouts of America.

There are several biological criteria that should be considered when nature reserve location is discussed. A particular site should be surveyed to see if it has optimal habitat for one or more species of special concern. Areas with maximum habitat and species richness should be sought. Sites of maximum endemicity are of great value, especially for retention of biotic diversity (Soule and Simberloff 1986). Tamaulipan brushland habitat satisfies all of these criteria, and therefore acquisition of the few remaining native brush tracts in LRGV is appropriate.

Conservation of biological diversity is accomplished best by management of a variety of habitats (Moore 1969). Matamoran District Tamaulipan brushland habitat contains riparian forest, upland thornscrub, wooded potholes, and other diverse biotic communities. Natural areas such as these, with minimal human disturbance, are valuable for purposes other than economic exploitation. They serve as outdoor classrooms and provide living models of how complex organisms interact in biotic communities (Gehlbach 1975; Janzen 1986). Additional knowledge of undisturbed ecosystems is needed as a baseline against which to measure effects of human modifications (Jenkins and Bedford 1975). Natural areas also serve as living banks of genetic diversity (Gehlbach 1975; Janzen 1986) and provide aesthetic, historical, therapeutic, and intrinsic values associated with wildlands (Rolston 1981, 1985).

Most land developments are pernicious to native flora and fauna and largely irreversible. Such developments often undergo depreciation of benefits with time, whereas environmental assets are enhanced with time (Dearden 1978). For example, in LRGV, developers may be uncritically accepting the philosophy that the only "good" stream is a "harnessed" stream (Hamilton 1971). For example – there has been discussion of water in the Rio Grande that flows "wasted" into the Gulf of Mexico. Ecologically speaking, this idea has no basis, because in nature things are recycled, not "wasted."

Some species in LRGV are in danger of becoming "orphan species" (i.e., those on the brink of extinction because their natural habitats are destroyed; Temple 1981). These animals and plants can serve as indicators of larger environmental problems that may have major adverse effects on humans (Pister 1979). Preservation of plants and animals ensures protection of any anthropocentric values that they possess but that research has not yet revealed (Pister 1979). Thus, it is in our best interests to preserve natural habitats such as Tamaulipan brushland of LRGV not only because of current ecological and aesthetic benefits, which would be lost if remnants were not conserved and human perturbations not restricted, but also because of inevitable future benefits.

Current concern for preservation, acquisition, and appropriate management of the resources of the Tamaulipan brushland of LRGV is illustrated by the broad range of support provided by local organizations. This support also is reflected in the concerted efforts of conservation organizations to provide funding for land acquisition in LRGV. For example, 13 national and international conservation organizations prepared a report on potential use of Land and Water Conservation Fund monies in Fiscal Year 1989 that listed purchase of 5,062 ha (12,500 acres) in LRGV as a major conservation need (American Hiking Society et al. 1988). At present, the LRGV NWR is the number one priority project for the USFWS with regard to use of Land and Water Conservation funding. To date, insufficient funding has limited acquisition to less than 25% of the projected need for land protection.

The exceptional concentration of wildlife in native brushland in LRGV, the presence of numerous endangered species and many species at the northern limits of their range, and the limited extent of brushland in both the United States and Mexico emphasize the value of remaining natural habitat. Losses of this habitat to date, approximately 95%, and continued destruction through conversion of brushland to agricultural, urban, and recreational lands further emphasize the need for acquisition, preservation, enhancement, and reestablishment of native vegetation and wildlife communities. There is almost unanimous agreement on the uniqueness and value of the biological diversity and natural communities remaining in LRGV, but no other Refuge acquisition program has to cope with an area in which so little of the original habitat remains. Plant and animal communities of LRGV are unique in the United States, and worthy of intensive conservation efforts. The need for preservation is imperative and the extreme value of all tangible results is clear.

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Each citation below is followed by one or more acronyms (the list of acronyms is arranged as presented in the text) to indicate its major subject matter; references followed by an asterisk (*) are cited in the text. Acronyms are defined as follows:

AG	=	Agriculture
BC	=	Brush Control – General
BCFI	=	Brush Control – Fire
BCHB	=	Brush Control – Herbicides
BCMC	=	Mechanical Brush Clearing
E	=	Environmental Ethics
GR	=	Grazing
LD	=	Location and Description
PM	=	Present Management
PT	=	Pesticides
UR	=	Urbanization
VE	=	Vegetation – General Ecology
VI	=	Vegetation – Impacts
WD	=	Water Development
WE	=	Wildlife – General Ecology
WI	=	Wildlife – Impacts

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

An extensive literature search and data synthesis were conducted on Matamoran District Tamaulipan Brushland in the Lower Rio Grande Valley of South Texas. The goal of the synthesis was to provide a single-source reference of historical review, land use planning, and management of brushland habitats and wildlife populations of the Lower Rio Grande Valley.

Tamaulipan brushland is a unique exosystem, found only in south Texas and northeastern Mexico. Since the early 1900's, 95% of native Tamaulipan brushland has been cleared for agriculture, urban development, and recreation. In riparian areas, 99% of native brush has been destroyed. Clearing destroys habitat of native species of plants and animals in the Lower Rio Grande Valley, and it may cause extinction of many species. Water development on the Rio Grande has substantially reduced river flow, resulting in altered riparian habitats and additional brush clearing.

The resource protection and management strategy for the Lower Rio Grande Valley consists of five integrated approaches: concentration of biotic community needs; maintenance of a wildlife habitat corridor; safeguarding of anchor untis of large size; protection of smaller management units; and the incorporation of 20 habitat islands into the management plan.

17. Document Analysis a. Descriptors

Tamaulipan brushland, south Texas, Tamaulipas, land clearing, pesticides, herbicides, corridor, endangered species, water development, Rio Grande, riparian habitat; resource protection, island biogeography, Matamoran District

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