OCELOT RECOVERY PLAN

(*Leopardus pardalis*)

DRAFT FIRST REVISION

Original Approval: August 22, 1990

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

DISCLAIMER

The Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.), requires the development of recovery plans for listed species, unless such a plan would not promote the conservation of a particular species. In accordance with section 4(f)(1) of the Act and to the maximum extent practicable, recovery plans delineate actions which the best available science indicates are required to recover and protect listed species. Plans are published by the U.S. Fish and Wildlife Service (USFWS), and are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than the USFWS. They represent the official position of USFWS only after they have been signed by the Regional Director. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions. Please check for updates or revisions at the website below before using.

The ocelot (*Leopardis pardalis*) is listed throughout its range including 22 countries. The United States (U.S.) contains only a small proportion of the ocelot's range and habitat. Recovery of endangered species is the fundamental goal of the ESA. Recovery planning is addressed in Section 4(f)(1) of the ESA. However, the USFWS has limited resources and little authority to address the major threats to the ocelot's recovery outside its own borders (killing and habitat destruction). Also, our knowledge regarding the status of the species in much of its range is very limited, and we lack the resources and authority to coordinate large scale international research and recovery for the entire species. Therefore, it is not practicable to establish site-specific management actions, objective and measurable recovery criteria, or cost estimates throughout the species' entire range. However, we have an established relationship with Mexico to address a number of issues of mutual concern, including managing cross-border populations of rare and endangered species. Because the USFWS's limited resources are better applied to planning and on-the-ground implementation of conservation actions within the boundaries of the U.S. and in partnership with adjacent Mexico, we focused this plan on two management units that cover the entire subspecies *L. p. sonoriensis* and *L. p. albescens* (see Figure 3, page 87). We also summarized information available in scientific literature regarding the status and threats to the ocelot throughout its range, and recommended general actions and criteria for addressing these threats and evaluating range-wide recovery, that may be applied, or refined, in the future.

Literature citation of this document should read as follows:

U.S. Fish and Wildlife Service. 2010. Draft Ocelot *(Leopardus pardalis*) Recovery Plan, First Revision. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico.

Copies may be obtained on line (species search, ocelot):
http://www.fws.gov/endangered

or by contacting:

U.S. Fish and Wildlife Service
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The U.S. Fish and Wildlife Service would also like to thank the Implementation Subcommittee of the Bi-National Ocelot Recovery Team for their participation and valuable insights provided during the development of this plan, and for all the work they do to conserve and recover ocelots. We look forward to future collaboration with the following individuals and others without whom ocelot recovery will not succeed: Alfonso Banda, Don Blanton, Doug Booher, Marylou Campbell, Jorge Cardenas, Karen Chapman, Hollie Colahan, Michael Corbett, Dave DeLaney,

Oscar Ramirez Flores, Paul Gheno, Melissa Grigione, Aaron Haines, Karen Hunke, Mark Iglesias, Jan Janeka, Scotty Johnson, Terry Johnson, Stacy McReynolds, Brent Ortego, Eva Sargent, Mitch Sternberg, Sylvia Waggoner, Lisa Williams, and Roberto Wolf.

Dedication

DAVID Steffen MAEHR, PhD,
SEPTEMBER 18, 1955 – JUNE 20, 2008

The USFWS and the Ocelot Recovery Team are honored to dedicate this plan to the memory of Dave Maehr, with the hope that the objectives within it may be achieved for the benefit of the ocelot and the ecosystem in which it plays a role.

Dave Maehr was named co-leader of the Bi-National Ocelot Recovery Team by the U.S. Fish and Wildlife Service's Southwest Regional Director, and served in that role from the first team meeting in May 2003 until June 2008 when he tragically died in a single-engine plane accident. As United States leader, Dave had primary responsibility for guiding the team to meet the USFWS's standards, policies, and priorities.

Dave was Professor of Conservation Biology in the Department of Forestry at the University of Kentucky, Lexington, and was known internationally as a world expert on large carnivores, most notably black bear and Florida panther, and for the reintroduction of the elk population in eastern Kentucky. He was an accomplished scientist, author and editor, and has been described as the "quintessential field biologist; outdoorsman, highly observant, an incredible naturalist, wonderful at handling animals, and talented artist and photographer."

Although he did not have previous experience with ocelots, Dave accepted the challenge of leading the Ocelot Recovery Team with humility, enthusiasm, and commitment. He worked closely with the USFWS to assure that scientific and policy standards were met, and with his Mexican co-leader to integrate the objectives of both countries. Dave also brought his considerable facilitation and editorial skills to bear in knitting the contributions of the entire team into a cohesive and focused recovery plan. Along with a ferocious intellect, Dave brought a gracious and light-hearted presence to his role as team co-leader. Finally, he never lost sight of the importance of considering human communities in conserving endangered species.

EXECUTIVE SUMMARY

DRAFT OCELOT RECOVERY PLAN, FIRST REVISION

Current Status of the Species

The ocelot (*Leopardus pardalis*) is listed as endangered throughout its range in the western hemisphere where it is distributed from southern Texas and southern Arizona through Central and South America into northern Argentina and Uruguay. The ocelot is listed as endangered by the State of Texas and is protected from hunting and live collection in Arizona where it is listed as a species of "special concern." In the 1982 final rule (47 FR 31670), the Service made a determination that the designation of critical habitat was not prudent because such a designation would not be in the best interests of conservation of the species. Currently the Texas population has fewer than 50 ocelots, found in 2 separated populations in southern Texas, at the northern limit of the species' distribution. As of February 2010, there were fewer than 25 total known individuals in the 2 populations in south Texas, with the possibility that more cats inhabit surrounding ranches. A third and much larger population of the Texas/Tamaulipas ocelot (*L. p. albescens*) occurs in Tamaulipas, Mexico, but is geographically isolated from ocelots in Texas. In November 2009, an ocelot (*L. p. sonoriensis*) was documented in Arizona (in Cochise County) with the use of camera traps (Sky Island Alliance 2010, unpubl. data). Additionally, in April 2010, an ocelot was found dead on a road near Globe, Arizona, and a genetic analysis is underway to determine the origin of this specimen, although preliminary data indicate the young male ocelot was not of captive origin (Arizona Game and Fish Department 2010, unpubl. data). Prior to these findings, the last known ocelot in Arizona was lawfully shot on Pat Scott Peak in the Huachuca Mountains in 1964 (Hoffmeister 1986, Lopez Gonzalez et al. 2003). In addition to the recent Arizona sightings, a number of ocelots have been documented just south of the U.S. border in Sonora, Mexico. While this plan considers the ocelot throughout its range, its major focus is on two cross-border management units, the Texas/Tamaulipas Management Unit (TTMU) and the Arizona/Sonora Management Unit (ASMU). Establishing management units is a useful tool for species occurring across wide ranges with multiple populations, varying ecological pressures, or different threats in different parts of their range. By using this approach, we were able to set recovery goals for each unit and will be able to measure their contribution toward recovery.

Habitat Requirements, Threats, and Other Limiting Factors

Habitats used by the ocelot throughout its range vary from tropical rainforest, pine forest, gallery forest, riparian forest, semi-deciduous forest, and dry tropical forest, to savanna, shrublands, and marshlands. In south Texas, the ocelot inhabits dense thornscrub[1] communities on Laguna Atascosa National Wildlife Refuge (LANWR) and on private lands in three Texas counties. The ocelot requires dense vegetation (>75% canopy cover), with 95% cover of the shrub layer preferred in Texas. Its prey consists primarily of rabbits, rodents, birds, and lizards.

[1] In a number of ocelot publications the term "thornshrub" is used instead of thornscrub. These terms are interchangeable. The term thornscrub is used in this document.

Habitat conversion, fragmentation, and loss comprise the primary threats to the ocelot today. Human population growth and development continue throughout the ocelot's range. In Texas, more than 95% of the dense thornscrub habitat in the Lower Rio Grande Valley has been converted to agriculture, rangelands, or urban land uses. Small population sizes in Texas and isolation from conspecifics in Mexico threaten the ocelot in Texas with inbreeding. Connectivity among ocelot populations or colonization of new habitats is inhibited by road mortality among dispersing ocelots. Issues associated with border barrier development and patrolling the boundary between the United States and Mexico further exacerbate the isolation of Texas and Arizona ocelots from those in Mexico. Commercial exploitation and illegal hunting were significant threats to the species when the ocelot was originally listed. Although some hunting of the ocelot continues, and regulations remain challenging to enforce, the harvest and export of ocelots has significantly declined and is controlled by the Convention on International Trade of Endangered Species (CITES).

Recovery Strategy

The strategy for recovery involves: the assessment, protection, reconnection, and restoration of sufficient habitat to support viable populations of the ocelot in the borderlands of the U.S. and Mexico; the reduction of effects of human population growth and development to ocelot survival and mortality; the maintenance or improvement of genetic fitness, demographic conditions, and health of the ocelot; the assurance of long-term viability of ocelot conservation through partnerships, the development and application of incentives for landowners, application of existing regulations, and public education and outreach; the use of adaptive management, in which recovery is monitored and recovery tasks are revised by the USFWS in coordination with the Ocelot Recovery Implementation Team as new information becomes available; and the support of international efforts to ascertain the status of and conserve the ocelot south of Tamaulipas and Sonora.

Recovery Goals

The goal of this revised recovery plan is to recover and delist the ocelot, with downlisting from endangered to threatened status as an intermediate goal.

Recovery Criteria

Reclassification from endangered to threatened may be considered when:

1. Populations south of Tamaulipas and Sonora continuously qualify for "Least Concern" under the International Union of Concerned Scientists (IUCN) Red List criteria (World Conservation Union, 2006, http://www.iucnredlist.org) for five years; and threats from habitat loss, habitat fragmentation, and poaching have been reduced such that the ocelot is no longer in danger of extinction.

2. The Texas/Tamaulipas (TTMU) population is estimated through reliable scientific monitoring to be above 200 in Texas and 1,000 in Tamaulipas for at least 5 years. The 200 ocelots in Texas should be distributed as either (1) a single core population of at least 150 ocelots with

interchange between it and ocelots in Tamaulipas that is sufficient to maintain genetic variability; or (2) at least 2 core populations of 75 ocelots each, with interchange between the 2 core populations and between the core populations and ocelots in Tamaulipas that is sufficient to maintain genetic variability. Interchange may be facilitated by moving ocelots between populations to simulate natural dispersal and recruitment. Core populations may include the current populations at LANWR and in Kenedy-Willacy Counties, but may also include a reintroduced population established within currently unoccupied historical range. Habitat protection must be in place to support core ocelot populations for the foreseeable future, and potential corridors and mechanisms must be identified to restore habitat connectivity between core populations.

3. The Arizona/Sonora Management Unit (ASMU) population is estimated through reliable scientific monitoring to be above 1,000 animals for 5 years. Habitat linkages to support an ASMU metapopulation have been identified. Threats to this population have been identified and are determined to be below the threshold of endangerment of extinction within the foreseeable future. Methods to address significant threats have been identified.

The ocelot should be considered for removal from the list of threatened and endangered species when:

1. Populations south of Tamaulipas and Sonora continue to qualify for "Least Concern" under the IUCN Red List criteria (World Conservation Union, 2006, http://www.iucnredlist.org) for 10 years and populations are stable or increasing; and threats from habitat loss, habitat fragmentation, and poaching are reduced such that the ocelot can maintain healthy, viable populations for the foreseeable future.

2. The TTMU population is estimated through reliable scientific monitoring to be above 200 in Texas and 1,000 in Tamaulipas for at least 10 years. The 200 ocelots in Texas should be distributed as either (1) a single core population of at least 150 ocelots with interchange between it and ocelots in Tamaulipas that is sufficient to maintain genetic variability; or (2) at least 2 core populations of 75 ocelots each, with interchange between the 2 core populations and between the core populations and ocelots in Tamaulipas that is sufficient to maintain genetic variability. Interchange among populations must occur through natural dispersal rather than by moving ocelots between population; or (3) if natural interchange between Texas and Tamaulipas is impossible, cross-border interchange may be facilitated by moving ocelots to simulate natural dispersal and recruitment *and* an additional population of at least 75 ocelots is established within currently unoccupied historical range in Texas. This additional population should be established in a location that would expand the geographical range of the species in Texas to provide sufficient insurance against loss of the entire Texas population from catastrophic weather events or infectious disease. Habitat protection must be in place to support and connect all core ocelot populations within Texas and within Tamaulipas for the foreseeable future.

3. The ASMU population is estimated through reliable scientific monitoring to be above 1,000 animals for 10 years. Significant threats to this population have been identified and addressed. Habitat linkages to facilitate an ASMU metapopulation have been identified and are conserved for the foreseeable future.

Actions Needed

- Assess, protect, and enhance ocelot populations and habitat in the borderlands of the U.S. and Mexico;
- Reduce the effects of human population growth and development on the ocelot;
- Maintain or improve genetic fitness, demographic conditions, and health of the ocelot in borderland populations;
- Assure the long-term success of ocelot conservation through partnerships, landowner incentives, community involvement, application of regulations, and public education and outreach;
- Practice adaptive management in which recovery is monitored and recovery tasks are revised by USFWS in coordination with recovery implementation team subgroups as new information becomes available; and,
- Support efforts to ascertain the status and conserve ocelot populations south of Tamaulipas and Sonora.

Total Estimated Actual Cost of Recovery (in U.S. dollars)[1]

Year	Priority 1a	Priority 1b	Priority 2	Priority 3	Total
2010	1,817,000	345,500	5,054,000	1,628,000	8,844,500
2011	1,802,000	280,500	5,225,000	2,068,000	9,375,500
2012	1,787,000	275,500	4,972,000	1,680,000	8,714,500
2013	1,787,000	262,500	5,027,000	2,144,000	9,220,500
2014	1,787,000	237,500	4,752,000	1,918,000	8,694,500
2015	1,787,000	227,500	4,284,000	1,955,000	8,253,500
2016+	1,787,000	237,500	4,109,000	1,634,000	7,767,500
Total	12,554,000	1,866,500	33,423,000	13,027,000	60,870,500

[1]Priority definitions can be found in section 3.2.

Date of Recovery

If recovery efforts are fully funded and carried out as outlined in this plan, recovery criteria for downlisting could be met by 2030. Based on continued recovery actions outlined and implemented into the future, we estimate that delisting for the ocelot could be initiated by 2040.

RESUMEN EJECUTIVO

PLAN DE RECUPERACIÓN DEL OCELOTE

Estatus Actual de la Especie

El ocelote en el hemisferio Oeste, está dentro de la lista de especies en peligro de extinción en todo su rango y se distribuye desde el sur de Texas, pasando por Centro y Sudamérica, hasta el norte de Argentina y Uruguay. También, el ocelote está listado como en peligro de extinción para el Estado de Texas y está protegido de la caza o captura de animales vivos en Arizona, donde está en la lista de especies de "protección especial". En la regla final de 1982 (47 FR 31670), el USFWS hizo la determinación de que la designación del hábitat critico no era prudente, debido a que esta designación podría no estar estipulada en la conservación de esta especie. En este momento la población de ocelote de los E.U. posee menos de 50 individuos, los cuales se encuentran en el Sur de Texas, en 2 poblaciones separadas. Estas poblaciones representan el límite norte de distribución para la especie. En Febrero del 2010, se estimó que había menos de 25 individuos en las dos poblaciones reconocidas para Texas, pero con la posibilidad que mas ocelotes puedan habitar en Ranchos aledaños a estas poblaciones. Una tercera población y de mayor tamaño de la especie de ocelote que habita Texas (*Leopardus pardalis albescens*), habita en Tamaulipas, México. Sin embargo, la población de Tamaulipas está geográficamente separada de la población de Texas. El ocelote de Sonora (*Leopardus pardalis sonoriensis*) fue documentado por última vez en Arizona en 1964, pero en este momento aun habita el Noroeste de México. Sin embargo, se sabe muy poco sobre su abundancia y distribución. Aunque este plan considera al ocelote dentro de todo su rango, el mayor enfoque se da en dos unidades de manejo de la frontera, que son: la Unidad de Manejo Texas/Tamaulipas (TTMU) y la Unidad de Manejo Arizona/Sonora (ASMU). El establecer unidades de manejo, es una herramienta adecuada para especies que habitan en rangos amplios y con poblaciones múltiples, pues existe variación en presiones ecológicas, o diferentes amenazas en los diferentes rangos. Al utilizar este aproche, nosotros pudimos establecer metas de recuperación por cada unidad y también podremos medir su contribución hacia la recuperación de la especie.

Requerimientos de Hábitat, Amenazas, y Otros Factores Limitantes

El ocelote requiere de vegetación densa (>75% de cobertura), con preferencia del 95% de cobertura en Texas. Dentro de los hábitats utilizados por el ocelote dentro de su rango de distribución, se encuentran: la selva tropical, el bosque de pino, el bosque ripario, el bosque sub-caducifolio, la selva tropical baja, la sabana, las áreas pantanosas y de matorral. Las áreas de vegetación contiguas son necesarias para permitir los movimientos de dispersión del ocelote. En el sur de Texas, el ocelote habita en las comunidades de matorral denso del Refugio de Fauna Silvestre de Laguna Atascosa y también en tierras privadas de 3 condados. Sus presas consisten principalmente en conejos, roedores, aves, y reptiles.

La conversión, la fragmentación y la pérdida de hábitat, comprenden las principales amenazas para el ocelote en nuestros días. La población humana y el desarrollo urbano se ha incrementado en todo el rango de distribución del ocelote. En Texas, más del 95% del matorral denso del Valle del "Lower Rio Grande" se ha convertido en campos de agricultura, ranchos, o en terrenos urbanos. Al tener la población de ocelote un tamaño pequeño y al mismo tiempo al estar aislada de las poblaciones co-específicas de México, crean una mayor amenaza para el ocelote en Texas, pues el banco genético es muy pobre y existe una alta posibilidad de daño en la población por factores externos. La conectividad entre las poblaciones de ocelote y la colonización de nuevas áreas por ocelotes en Texas, se ven afectadas por la proliferación de carreteras lo que conlleva a una alta incidencia de atropellamientos de ocelotes en movimientos de dispersión. Las actividades en la frontera entre los Estados Unidos y México, incrementan el aislamiento de los ocelotes de Texas con los de México. La explotación comercial y la caza furtiva fueron amenazas significativas cuando al ocelote se le incluyo en la lista de especies en peligro de extinción. Aunque todavía existe caza (ilegal) del ocelote en algunas partes de su rango y es muy difícil el implementar regulaciones en áreas rurales, la explotación y la exportación de los ocelotes han disminuido significativamente y ahora es controlada por el CITES.

Estrategia de Recuperación

La estrategia de recuperación involucra: la evaluación, protección, reconexión y restauración de suficiente hábitat para poder soportar las poblaciones viables de ocelote en las regiones fronterizas de los E.U. y México; la reducción de los efectos del crecimiento de la población humana y el desarrollo urbano que causan mortalidad y baja supervivencia del ocelote; el mantenimiento e incremento de la variabilidad genética, condiciones demográficas y salud del ocelote; el aseguramiento del mantenimiento a largo plazo de la viabilidad de la conservación del ocelote a través de acuerdos, incentivos para los dueños de la tierra, la aplicación de la regulación existente, y la educación del público en general; el uso de un manejo adaptable, en donde la recuperación es evaluada y las tareas de recuperación son revisadas por el USFWS en coordinación con el Grupo de Recuperación (Recovery Team) de acuerdo a la nueva información que se vaya generando; y el apoyar los esfuerzos internacionales para mantener el estatus y al mismo tiempo conservar al ocelote al sur de Tamaulipas y Sonora.

Metas de Recuperación

La meta de este plan de recuperación es el recuperar al ocelote y al mismo tiempo retirarlo de la lista de especies en peligro de extinción y como meta intermedia colocarlo en la lista de especies amenazadas.

Criterio de Recuperación

El ocelote puede ser removido de la lista de especies amenazadas y en peligro de extinción cuando:

1. Las poblaciones al sur de Tamaulipas y Sonora continúen en la calificación de "baja importancia" por la Unión Internacional de Científicos (UICN) criterio de Lista Roja (World Conservation Union, 2006, http://www.iucnredlist.org) por cinco años y las poblaciones se mantengan estables o en incremento. Y cuando las amenazas de la pérdida de hábitat y fragmentación del mismo y la cacería ilegal se hayan reducido del tal manera que al ocelote

mantenga poblaciones viables y ya no se le considera en peligro de extinción en un futuro cercano.

2. La población de ocelote de la Unidad de Manejo Texas-Tamaulipas (TTMU) es estimada a través de monitoreos científicos confiables, de ser de más de 200 ocelotes en Texas y más de 1000 para Tamaulipas, por un período de por lo menos 10 años. Los 200 ocelotes en Texas deberán de estar distribuidos ya sea (1) como una sola población núcleo de por lo menos 150 individuos con contacto e intercambio con los ocelotes de Tamaulipas y que con esto sea suficiente para mantener la variabilidad genética: o (2) por lo menos dos poblaciones núcleo de 75 ocelotes cada una con contacto e intercambio con los ocelotes de Tamaulipas y que con esto sea suficiente para mantener la variabilidad genética. El intercambio entre las poblaciones deber de ser debido a la dispersión natural en lugar de mover los ocelotes de una población a otra. Alternativamente, si el intercambio natural y/o entre las fronteras no es posible, una tercera población de por lo menos 75 ocelotes debe de establecerse dentro del rango histórico pero no ocupado en Texas. Esta tercera población debe de establecerse en un área que pueda expandir el rango geográfico de la especie en Texas y que pueda prever la pérdida de la población entera de Texas debido a una catástrofe. La protección del hábitat debe de estar sujeto para apoyar y conectar por lo menos dos poblaciones de ocelote núcleo en el futuro cercano en Texas.

3. La población de ocelote de la Unidad de Manejo Sonora-Arizona (ASMU) es estimada a través de monitoreos científicos confiables, de ser de más de 1000 ocelotes por 10 años. Las amenazas significativas para esta población se han identificado y tomado en cuenta. Los lazos de hábitat para facilitar una meta-población en Sonora y Arizona se han identificado y estan protegidos para un futuro cercano.

Acciones que se Necesitan

- Evaluar, proteger e incrementar las poblaciones de ocelote y su hábitat en las regiones fronterizas ente México y los E.U;
- Reducir los efectos del desarrollo y crecimiento de la población humana en el ocelote.
- Mantener o incrementar el estado genético, las condiciones demográficas, y la salud del ocelote en las poblaciones fronterizas;
- Asegurar el éxito a largo plazo de la conservación del ocelote a través de acuerdos, incentivos para los dueños de la tierra, involucramiento de las comunidades, aplicación de los reglamentos, y educación del público en general;
- Prácticas de manejo en donde la recuperación es evaluada y las tareas de recuperación son revisadas por el USFWS en coordinación con el Grupo de Recuperación (Recovery Team) y subgrupos de acuerdo a la nueva información que se vaya generando;
- Apoyar los esfuerzos para establecer el estatus y conservar las poblaciones al sur de Tamaulipas y Sonora.

Costo Total Estimado de la Recuperación del Ocelote en U.S. dolares.

Year	Priority 1a	Priority 1b	Priority 2	Priority 3	Total
2010	1,817,000	345,500	5,054,000	1,628,000	8,844,500
2011	1,802,000	280,500	5,225,000	2,068,000	9,375,500
2012	1,787,000	275,500	4,972,000	1,680,000	8,714,500
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Total	12,554,000	1,866,500	33,423,000	13,027,000	60,870,500

Fecha de Recuperación

Si los esfuerzos de recuperación son completamente financiados y llevar a cabo el resume escrito del plan de recuperación, el criterio de recuperación para bajar este especie de la lista en peligro de extinción a amenazada puede ser hecho para el año 2030. Basado en continuar las aciónes de recuperación por el resume escrito y implementado para el futuro, nosotros estimamos quitar el ocelote de la lista amenazada para el año 2040.

Table of Contents

PART I: BACKGROUND

Introduction

The Endangered Species Act of 1973 (ESA) calls for preparation of recovery plans for threatened and endangered species likely to benefit from the effort, and authorizes the Secretary of the Interior to appoint recovery teams to prepare the plans (U.S. Congress 1988). According to section 4(f)(1) of the ESA, recovery plans must, to the maximum extent practicable, describe site-specific management actions as may be necessary to achieve the plan's goals, incorporate objective and measurable delisting criteria, and estimate the time and cost required for recovery. A recovery plan is not self-implementing, but presents a set of recommendations that are endorsed by an official of the Department of Interior for managers. Recovery plans also serve as a source of information on the overall biology, status, and threats of a species. It is the intent of the U.S. Fish and Wildlife Service (USFWS) to modify this recovery plan in response to management, monitoring, and research data.

The first recovery plan for the ocelot, *The Listed Cats of Texas and Arizona Recovery Plan (With Emphasis on the Ocelot)*, was completed in 1990 (USFWS 1990). This plan briefly addressed the jaguar, jaguarundi, and margay, and focused on the ocelot, primarily in Texas.

While considerable progress was made in conducting ocelot research in Texas, a number of recovery actions have received little attention. In addition, the demographic, economic, and political landscapes in south Texas, Arizona, and northern Mexico have changed since 1990. Finally, there is a need to address the ocelot as it is listed, throughout its range. In May 2003, a new bi-national ocelot recovery team was formed to revise the outdated plan. The team is composed of both Technical and Implementation subgroups with representation from the United States and Mexico. The Technical subgroup is composed of 10 scientists, researchers, and biologists with expertise in feline biology and ecology, genetics, landscape ecology, and conservation planning. The Technical subgroup's function is to compile and review extensive scientific information and develop recovery goals, criteria, strategies, and recommended actions. The Implementation subgroup consists of a broad range of interested parties including landowners, conservation organizations, biologists, academics, and state and Federal agencies. The role of the Implementation subgroup is to assist the USFWS in developing an effective strategy for, and implementing the recovery actions developed through, the ocelot recovery planning process.

Because the ocelot is listed throughout its range, which includes 22 countries, the ocelot presents a significant challenge for recovery planning. Our knowledge regarding the status of the species in much of its range is very limited, and the USFWS and its partners lack the resources and authority to coordinate large scale international research and recovery for the entire species. Therefore, it is not practicable to establish site-specific management actions, objective and measurable recovery criteria, or cost estmates throughout the species' entire range. However, we can establish the framework to better understand the status and conservation needs of ocelots throughout their range by identifying research needs as outlined in the recovery actions of this plan. The USFWS needs information on populations and threats internationally in order to evaluate whether its current listing status is appropriate. However, the USFWS does not have the potential to address the major threats to the species' recovery outside the U.S. Because the USFWS's limited resources are better applied to planning and on-the-ground implementation of conservation actions within the boundaries of the U.S and in partnership with adjacent Mexico, we have established specific criteria for recovery, and actions that, if implemented, will conserve viable ocelot populations in the borderlands (Arizona-Sonora and Texas-Tamaulipas). Priority is being given to the two subspecies that occur in this area, *L. p. sonoriensis* and *L. p. albescens*, which are most likely to benefit from such plans because this is where the USFWS has the most jurisdiction and we have an established working relationship for issues of mutual concern with adjacent Mexico. Also, these subspecies are known to conflict with construction or other development projects or other forms of economic activity. If the criteria in this plan are met, we believe that it would be feasible and appropriate to consider downlisting or delisting these populations as either Distinct Population Segments (DPS) or subspecies units.

At this time, the Texas/Tamaulipas Management Unit (TTMU) and the Arizona/Sonora Management Unit (ASMU) are only "potential" DPSs or subspecies units and cannot be considered for delisting separately from the listed entity (i.e., the entire species) until meeting both the recovery criteria for each management unit and the USFWS has completed a formal listing evaluation and designation, which would involve a proposed rulemaking, public review and comment, and a final rulemaking. The USFWS understands that a future listing of ocelot in the TTMU and ASMU as subspecies or DPSs are not guaranteed. In 1996, USFWS and National Marine Fisheries Service (NMFS) published a joint policy defining the phrase "distinct population segment" (USFWS and NMFS 1996, 61 FR 4722). Three elements are considered in a decision regarding the listing, delisting, or reclassification of a DPS as endangered or threatened under the ESA: discreteness of the population segment in relation to the remainder of the species, significance of the population segment to the species, and conservation status.

Thus, our approach in this revision to the ocelot portion of the 1990 recovery plan is as follows:

- This plan focuses exclusively on the ocelot.

- We summarize what is known about the status of the ocelot throughout its range and identify primary information gaps and broad actions necessary to address conservation of the species outside of the borderlands of the U.S. and Mexico.

- We address in detail the actions necessary to conserve the existing and highly imperiled breeding populations in Texas and their source population across the border in Tamaulipas, Mexico.

- We address the status of the existing population in Arizona and Sonora, Mexico, and identify the actions necessary to understand its status and to conserve the population through cooperative efforts in the borderlands of Arizona/Sonora.

We submit that the approach described above meets our statutory requirements to the maximum extent practicable. As our knowledge of the ocelot range-wide increases and as the recovery actions described in this plan are implemented, the plan may be revised and refined.

Status of the Species

The ocelot was upgraded to CITES Appendix I in 1986 (Fuller et al. 1987) and is considered endangered in Mexico by the Ley General del Equilibrio Ecologico (LEGEPA) (nom-ecol-059/94) (Vargas and Huerta 2001). The ocelot is one of the least known wild cat species of the world (Nowell and Jackson 1996) and its northernmost distribution occurs in southern Arizona and northwestern Mexico.

The ocelot in the U.S. is listed as endangered under the authority of the ESA. The species has a recovery priority number of 5C, meaning that it has a low potential for recovery with a relatively high degree of conflict with development projects. The ocelot was listed as endangered in 1972 under the authority of the Endangered Species Conservation Act of 1969 (USFWS 1972). The 1969 Endangered Species Conservation Act maintained separate lists for foreign and native wildlife. The ocelot appeared on the foreign list, but due to an oversight, not on the native list. Following passage of the Endangered Species Act in 1973 (ESA), the ocelot was included on the January 4, 1974, list of "Endangered Foreign Wildlife" that "grandfathered" species from the lists under the 1969 Endangered Species Conservation Act into a new list under the ESA (USFWS 1974). The entry for the ocelot included "Central and South America" under the "Where found" column in the new ESA list. Endangered status was extended to the U.S. portion of the ocelot's range for the first time with a final rule published July 21, 1982 (USFWS 1982). The "Historic range" column for the ocelot's entry in the rule reads, "U.S.A. (TX, AZ) south through Central America to South America." The entry on the current list (USFWS 2003) is essentially the same, and reads, "U.S.A. (TX, AZ) to Central and South America" (Figure 1).

In Arizona, the ocelot is included on the Arizona Game and Fish Department's (AGFD) list of *Species of Greatest Conservation Need* in Arizona's Comprehensive Wildlife Conservation Strategy: 2005-2015 (http://www.azgfd.gov/w_c/cwcs_downloads.shtml). This conservation strategy provides policy guidance to both state and Federal agencies and the public on AGFD's priorities. It does not provide specific legal or regulatory protection for listed species. However, the general provisions of Arizona Revised Statutes Title 17 protect all native wildlife, including federally-listed species.

In Texas, the ocelot is protected by state law and has state endangered species status (Texas Parks and Wildlife Department 2007). The Texas Parks and Wildlife Department (TPWD) is the state agency responsible for protection of the ocelot in Texas.

Status South of the U.S. – We briefly review the status of the ocelot outside U.S. boundaries below. Please see Appendix III of this document for a more complete, fully cited review of ocelot status and threats in other countries.

The ocelot is found in every mainland country south of the U.S. except Chile, and 11 subspecies have been described (Pocock 1941, Cabrera 1961, Hall 1981, Eizirik et al. 1998). International trade of the ocelot was banned by CITES in 1975 in response to dwindling populations throughout its range, and as of 1990, all ocelot subspecies are listed under Appendix I, as a species threatened with extinction. The IUCN Red List, formed by the World Conservation

Union (2006, http://www.iucnredlist.org), lists the ocelot as Least Concern (populations estimated to be at least 50,000), except for the Texas subspecies, *Leopardus pardalis albescens*, which meets criteria D (populations less than 250 adults) and is endangered. There is very little information regarding actual population status south of the U.S. As a widespread species with cryptic habits and a low population density in any one country, understanding the ocelot's status requires not only scientific knowledge of its distribution, ecological requirements, and population dynamics, but also an appreciation for international relations.

Ocelot population density estimates for particular habitats include: 5.7/100 km^2 for subtropical thornscrub to tropical deciduous forest in the province of Sonora, Mexico; 19.8/100 km^2 in tropical rainforest and 3.0/100 km^2 in pine forest in Belize; 2.8/5 km^2 for gallery forest, semi-deciduous forest, savanna, and marshlands of the Pantanal Reserve of southwestern Brazil; 0.8/5 km^2 in Amazon rainforest in both eastern and southern Peru; and 0.4/ km^2 and 1.9/ 5km^2 for the llanos (interspersed dry tropical forest in savanna) of central Venezuela. In the past 15 years, trapped animals or their sign were noted but no quantitative measures of population were approximated during studies conducted in the States of Campeche, Chiapas, Durango, Sinaloa, Tabasco, Tamaulipas in Mexico; and in Brazil; Costa Rica; Guatemala; Paraguay; and Venezuela. Tropical lowlands of eastern and southern Peru appear to support the highest known densities.

Many of the threats to the ocelot are common to all Latin American countries where most studies have occurred on nationally-recognized preserves. Threats generally include habitat loss, habitat fragmentation, logging, and harvest of the ocelot and its prey. Ocelot hunting varies between and within countries, and is legal in Ecuador, El Salvador, Guyana, and Peru.

Ocelot populations appear to be rebounding in parts of its range, perhaps due to a decrease of hunting since the end of the 1980s. In the absence of hunting the ocelot seems tolerant of human settlement and activities if large forests and sufficient prey are available.

Description and Taxonomy

The ocelot *(Leopardus pardalis*; Linnaeus, 1758) is a medium-sized spotted cat (Figure 2). The coloration of the upper parts of the body is pale gray to cinnamon. There are spots on the head, two black stripes on the cheeks, and four to five longitudinal black stripes on the neck. The body shows elongated black-edged spots arranged in chain-like bands. The rounded ears are black dorsally, with a conspicuous white spot. The underparts are whitish, spotted with black. The tail is marked with dark bars or incomplete rings (Hall 1981). The dental formula is i3/3, c1/1, pm3/2, m 1/1, for a total of 30 teeth. Weights range from 7-16 kg (15-35 lbs), with males weighing more than females.

The ocelot belongs to the genus *Leopardus* which also includes the margay *(Leopardus wiedii)* and the oncilla *(Leopardus tigrinus)*. The ocelot is further divided into as many as 11 subspecies that ranged from the southwestern U.S. to northern Argentina (Pocock 1941, Cabrera 1961, Eizirik et al. 1998). Two subspecies occurred in the United States: the Texas/Tamaulipas ocelot *(L. p. albescens)* and the Arizona/Sonora ocelot *(L. p. sonoriensis)* (Hall 1981) (Figure 3). For purposes of this recovery plan, we are using these common names for these subspecies.

Population Trends and Distribution

Fossils of ocelots have been reported from the U.S., primarily in California, Arizona, and Florida (Navarro-Lopez 1985). Ocelot fossils from North America include the proximal end of a right femur from Alachua County, Florida (Kurten 1965), and a left mandibular ramus from the Rancholabrean Reddick I fauna in Marion County, Florida (Ray et al. 1963, Kurten 1965). This sparse North America record may represent a brief extension of ocelot range during the Sangamonian paleo-environment (Werdelin 1985).

Although the exact date of habitation is unknown, a Native American archaeological site on the San Pedro River, near Redington, Arizona, had ocelot remains that predated the arrival of Spaniards (Burt 1961). There are no fossil records from Texas, but the ocelot probably occurred there in prehistoric times and may have ranged over much of the southern U.S. (Navarro-Lopez 1985). Moorehead (1968) reported a picture of an ocelot carved on human bone found in the Hopewell Mound Group in Ross County, Ohio, from between 1400 and 1500 A.D. Cahalane (1947) suggested this finding indicated the prehistoric range of the ocelot might have extended as far north as Ohio. However, Moorehead (1968) noted that many objects in the Hopewell burial mounds were the result of exchange with distant human populations.

The Texas/Tamaulipas ocelot once inhabited southern and eastern Texas, north to Hedley, Texas, and west to Marfa, Texas (Sealander 1979, Hall 1981). The type specimen for the Texas/Tamaulipas ocelot is from an unspecified locality in southwestern Arkansas along the Red River (Goldman 1943, Sealander 1979). The Texas/Tamaulipas ocelot may have also ranged into western Louisiana, but verified records from the Pleistocene are lacking (Ray et al. 1963, Kurten 1965, Lowery 1974, Navarro-Lopez 1985). Navarro et al. (1993) questioned whether *L. p. albescens* still occurred in Texas or whether it was represented by another subspecies. In Mexico, the Texas/Tamaulipas ocelot was found from the foothills of the Sierra Madre Oriental in Coahuila, through Nuevo Leon and Tamaulipas to the Gulf Coast. The Texas/Tamaulipas ocelot is isolated from the Arizona/Sonora ocelot by the Sierra Madre highlands, and the dry areas of the Mexican Plateau (Tewes and Schmidly 1987, Caso 1994).

The late 19th century range of the Arizona/Sonora ocelot (*Leopardus pardalis sonoriensis*) included southeastern Arizona as far north as Fort Verde (Cockrum 1960, Hall 1981). Hoffmeister (1986) questioned the validity of the Fort Verde specimen and believed its origin may have been Mexico or Texas. In Mexico, the Arizona/Sonora ocelot occurs in the foothills of the Sierra Madre Occidental and associated sky island ranges from northeastern Sonora south into northern Sinaloa (Hall 1981), but it is absent from the desert scrub of western Sonora.

Currently, the ocelot ranges from extreme southern Texas and southern Arizona (although recent documentation in Arizona is sparse) through the coastal lowlands of Mexico to Central America, Ecuador and northern Argentina. It does not occur south of the Province of Entre Rios in Argentina (Denis 1964, Redford and Eisenberg 1992). The ocelot also is known from Trinidad and Isla de Margarita, Venezuela, but not from the Antilles (Tewes and Schmidly 1987, Sunquist and Sunquist 2002). There are no recent verified reports of ocelots from California or Florida.

Between 1980 and 2010 the ocelot was documented in Texas by photographs or specimens in Cameron, Willacy, Kenedy, Hidalgo, and Jim Wells Counties (L. Laack and M. Tewes, unpublished records; Figure 4). The two U.S. ocelot populations occur in southern Texas (Tewes and Everett 1986). One occurs in Willacy and Kenedy Counties primarily on private ranches (Navarro-Lopez 1985) and the other in eastern Cameron County primarily on the Laguna Atascosa National Wildlife Refuge (LANWR; Laack 1991). Both populations are isolated from each other by at least 30 km and occupy remnant habitat fragments. Individuals have occurred outside of these two populations, but there is no recent evidence that a breeding population occurs in other areas of Texas. A male ocelot moved from the Willacy population to the Arroyo Colorado Unit of TPWD where he was photographed several times between 2000 and 2003 and again on January 16, 2006. The Arroyo Colorado Unit is located 18 miles southeast of the Yturria Ranch and 5 miles west of LANWR. The ocelot was trapped again on the Yturria Ranch during March 2006. Ocelots from LANWR have been found on the Arroyo Colorado Unit previously; therefore, this series of records represents the first documentation of an ocelot moving between the Willacy and Cameron populations in Texas. Genetic data suggest little or no interchange between the Cameron and Willacy-Kenedy populations (Walker 1997), although at least one male has moved back and forth between them during the period of 1996 to 2006 (USFWS 2010, unpubl. data). Also, genetic analyses indicate that little to no genetic exchange has occurred between Texas and Mexico populations in recent decades, and that both Texas populations have lost genetic diversity and become increasingly isolated (Janecka 2006).

In Texas, the effective breeding populations are estimated at 5.9 to 14.4 for Cameron and 2.4 to 3.6 for Willacy-Kenedy populations (Janecka 2006). In 2009, the USFWS estimated there to be 7 ocelots (2 adult females, 3 adult males, and 2 juveniles) using conservation easements in Willacy County based on camera-trapping (USFWS 2010, unpubl. data). Between November, 24, 2009 and March 19, 2010, 13 ocelots (8 adult males, 4 adult females, and 1 juvenile) were found on LANWR based on camera-trapping, live-trapping, and a single road-killed specimen (USFWS 2010, unpubl. data).

The first "endangered cats" recovery plan depicted "occupied habitat" in Jim Wells, Nueces, Live Oak, and Kleberg Counties, 50 miles (80 km) north of the Willacy-Kenedy population (USFWS 1990). Recent road kills (n=3) on SR-77 south of Kingsville (M. Tewes, personal communication, May 2003 Recovery Team meeting) suggest continued ocelot presence there, but there is no evidence of a reproducing population. Tuovila (1999) trapped 17 bobcats and 238 non-target animals, but no ocelots, in the southern half of Live Oak County and northernmost Jim Wells County in 1997 and 1998.

An adult, lactating female was tagged and radio-tracked from 1992 through 1996 along the Rio Grande River on and around Santa Ana NWR, where she "was possibly the only ocelot" in the study area (Fischer 1998). Fischer (1998) caught 21 bobcats, 300 non-target animals, and no ocelots in 8,304 trap-nights in Hidalgo County (the single ocelot in his study had been captured earlier). Shinn (2002) used camera traps and hair snares on 27 widely scattered tracts managed by the South Texas Refuges Complex (U.S. Fish & Wildlife Service), but did not find evidence of ocelot west of Brownsville on the Rio Grande River. He confirmed the presence of the species in extreme southern Cameron County and in extreme western Willacy County. Shinn (2002) felt that these latter animals probably were transient males that returned to nearby known population centers after failing to find mates. Highways, agriculture, and human development may inhibit dispersal by females into these areas (Shinn 2002). Similarly, Grassman et al. (2006) failed to document ocelot presence at Choke Canyon Reservoir in Live Oak and McMullen Counties, Texas, despite a 10-year increase in optimal ocelot cover.

A third and much larger population of the Texas/Tamaulipas ocelot subspecies occurs more than 200 km (~124 mi) south of the Texas/Mexico border in the Sierra of Tamaulipas, Mexico (Caso 1994). In February 2009, the Caesar Kleberg Wildlife Research Institute began camera trapping on Rancho Caracol, Mexico, which is located about 193 km (120 mi) south of the Texas/Mexico border. Box-trapping was done in December 2009 and February 2010 from which 11 ocelots were captured and radio-collared in 314 trap nights (S. Carvajal, 2010 pers. comm.). In addition, Chad Stasey found 33 different individuals on 120 km^2 using a remote sensing camera grid (A. Caso, 2010 pers. comm.).

The Arizona/Sonora ocelot subspecies (*L. p. sonoriensis*) occurs in southern Arizona and northwestern Mexico (Sonora and northern Sinaloa) (Sky Island Alliance 2010, unpubl. data; López-Gonzalez et al. 2003; Murray and Gardner 1997). Breeding populations occur in the States of Sonora and northern Sinaloa. Two other subspecies are present in the Pacific coast region of Mexico, *L. p. nelsoni* (including the States of Sinaloa, Nayarit, Jalisco, Michoacan, Guerrero, and parts of Oaxaca), and *L. p. pardalis* (in southern Oaxaca and Chiapas into Central America) (Murray and Gardner 1997).

The Arizona/Sonora ocelot is isolated from the Texas/Tamaulipas ocelot by the Sierra Madre highlands and the dry areas of the Mexican Plateau, and once ranged from southeastern Arizona into Mexico's States of Sonora and northern Sinaloa (Goldman 1943) (Figure 3). The type specimen for the Arizona/Sonora ocelot was taken along the Rio Mayo, near Camoa, Sonora (Goldman 1943). In November 2009, the first live ocelot was documented in Arizona (in Cochise County) with the use of camera traps (Sky Island Alliance 2010, unpubl. data). Additionally, in April 2010, an ocelot was found dead on a road near Globe, Arizona, and a genetic analysis is underway to determine the origin of this specimen, although preliminary data indicate the young male ocelot was not of captive origin (Arizona Game and Fish Department 2010, unpubl. data). Prior to these findings, the last known ocelot in Arizona was lawfully shot on Pat Scott Peak in the Huachuca Mountains in 1964 (Hoffmeister 1986, Lopez Gonzalez et al. 2003). In addition to the recent Arizona sightings, a number of ocelots have been documented just south of the U.S. border in Sonora, Mexico. Specifically, with the use of camera traps, at least 4 ocelots have been documented since February 2007 in the Sierra Azul, 30-35 miles southeast of Nogales; and 1 ocelot was documented in 2009 in the Sierra de Los Ajos, about 30 miles south of the U.S. border near Naco, Mexico. Lopez Gonzalez et al. (2003) obtained 36 verified ocelot records for Sonora, 21 of which were obtained after 1990. A population of 2,025 $\pm$ 675 ocelots in Sonora was estimated by Lopez Gonzalez et al. (2003) based on the distribution of these records and the availability of potential habitat. The original recovery plan (USFWS 1990) did not include recommendations or contingency plans in the event that the ocelot re-occupied southeastern Arizona.

Life History and Demography

Population size, home range, and density - Estimating population sizes of secretive nocturnal carnivores, especially species that inhabit dense vegetative cover, such as the ocelot, is difficult. Thus, it is challenging to generalize about the status and distribution of this species in the U.S. and northern Mexico. Tewes and Everett (1986) provided "a crude estimate" of 80-120 individuals in Texas based on distribution of radio-tagged ocelots extrapolated to areas that were probably suitable habitat. Based on several years of intensive study, Laack (1991) estimated a total of about 30 ocelots on LANWR during the mid-1980's and believed this was considerably higher than the population estimate from 5 years earlier. More recently, Haines et al. (2005a) estimated an effective population size (number of breeding individuals) in the LANWR population of 19 ocelots, and a total population of 38 ocelots in Cameron County. These estimates were calculated by averaging ocelot home range sizes reported by Navarro-Lopez (1985), Tewes (1986), and Laack (1991) and extrapolating this estimate to the amount of available dense thornscrub habitat. The mean home range size for adult male and female ocelots was 10.5 km^2 (SD = 5.1 km^2) and 6.5 km^2 (SD = 2.0 km^2), respectively. The amount of dense thornscrub habitat available in LANWR and a 22 km buffer around the refuge was 75 km^2. The average effective population size based on extrapolation includes 7 (range = 5-14) adult males and 12 (range = 9-17) adult females. Assuming adults equal half of the total population, a total population size of 38 ocelots was estimated for this population. Note that it is likely not all the available habitat is occupied by ocelots so the actual population estimates and densities are much less than what is determined by extrapolation.

In 2009, there were estimated to be 7 ocelots (2 adult females, 3 adult males, and 2 juveniles) using conservation easements in Willacy County based on camera-trapping (USFWS 2010, unpubl. data). Between November, 24, 2009, and March 19, 2010, 13 ocelots (8 adult males, 4 adult females, and 1 juvenile) were found on LANWR based on camera-trapping, live-trapping, and a single road-killed specimen (USFWS 2010, unpubl. data).

Emmons (1988) reported 0.8 ocelots (excluding transients) per km^2 at Cocha Cashu in Peru, a density she characterized as "high." Ludlow and Sunquist (1987) estimated 0.4 adult ocelots per km^2 on their study site in Venezuela. All of these estimates were based on the spatial distribution of radio-tagged animals and evidence of unmarked animals (tracks, scats and other sign). In the Chamela-Cuixmala Biosphere Reserve of western Mexico, Casariego-Madorell (1998) estimated 0.45 to 2.25 ocelots per km^2 based on camera traps, radio-telemetry, and capture-recapture methods. Fernandez (2002) estimated the density of ocelots in Chamela as 0.25 to 0.39 ocelots per km^2. Both of Fernandez's (2002) estimates were likely conservative; the lower estimate did not take overlap among ocelots into consideration. Smallwood and Schonewald (1996) documented a strong negative correlation between estimated population density and size of study area. Maffei et al. (2005) used camera trap surveys to estimate a mean of 0.3 adult ocelots per km^2 in Bolivian dry-forests and noted an association between ocelot density and mean annual precipitation.

Because of limited overlap among adult male ocelots (Tewes 1986, Laack 1991, Caso 1994) and among adult female ocelots (Laack 1991, Emmons 1988), home range size may help approximate population density. Most studies have been based on small numbers of animals and most researchers report that some untagged adults (especially females) occurred on their study sites, raising the possibility that females may be less territorial than indicated by measures of home range overlap. However, Emmons (1988) supported her data on low overlap between adult females with additional observations of interactions among females, and the observation that females concentrated their activity at the periphery of the home range such that the entire home range boundary was visited every two to four days.

Caso (1994), Fernandez (2002), Ludlow and Sunquist (1987), Konecny (1989), Martinez-Meyer (1997), Sunquist et al. (1989), and Dillon (2005) estimated home ranges of ocelots outside the U.S. In Texas, Tewes (1986) reported ocelot home range size of 18 km^2 (5 males) and 11 km^2 (3 females), using 95% harmonic mean estimators for ocelots on Willacy County ranches and LANWR. In contrast, Laack (1991) reported 3 male home ranges averaged 3.6 km^2 (95% harmonic mean) or 6.25 km^2 (minimum convex polygon), compared to 3 female home ranges that averaged 2.1 km^2 (harmonic mean) or 2.9 km^2 (minimum convex polygon) on LANWR. Laack attributed the smaller home ranges for ocelots on the same LANWR study area (including some of the same individual ocelots studied by Tewes) to a higher density of ocelots during the more recent study. This interpretation is supported by the fact that two female subadults captured in the earlier study did not disperse, but remained in their natal range as adults. The relatively long duration of dispersal (7 to 9.5 months) also suggested a lack of vacant territories during the latter study period. These results demonstrate considerable temporal variation in population size, and further indicate the utility of home range size as an index of population density.

Realistic estimates of population dynamics and distribution are fundamental to successful management and recovery of the ocelot. Use of noninvasive techniques to estimate species presence as well as population size would be a valuable tool for ocelot conservation. Application of automatically-triggered cameras can be used to detect ocelot presence (Heilbrun et al. 2003, Trolle and Kery 2003). Trolle and Kery (2003) used capture-recapture analysis of camera-trapping data to estimate ocelot density in the Brazilian Pantanal. Although they used an arbitrary method to estimate the area sampled by their cameras (this area forms the denominator of any density estimate), the sharp edges of suitable habitat in south Texas would obviate this hurdle if the camera array covered the entire area of interest. These methods have been used effectively for secretive species such as tiger (*Panthera tigris*) and will support the use of mark-recapture models in estimating population size (Karanth 1995, Karanth and Nichols 1998). Increasingly, evaluation of fecal DNA is being used to estimate population size and distribution of vertebrates (Kovach et al. 2003, Zuercher et al. 2003). In particular, small populations may benefit from a combination of population estimation approaches including remote-activated cameras, hair samples from snares, scat samples, and radio telemetry (Brown 2004).

<u>Age at first reproduction, litter size, birth interval</u> - There are few data on reproductive rates of wild ocelots. Eaton (1977) and Tewes and Schmidly (1987) summarized relevant data, mostly from studies of captive animals.

Gestation lasts about 70-80 days, and breeding reaches a peak during autumn in Texas (Tewes and Schmidly (1987). Interestrous periods of six weeks have been documented in captive animals (Eaton 1977). Wild ocelots probably first produce young at about 18 to 30 months-of-age (Eaton 1977, Tewes and Schmidly 1987). Laack (1991) observed first reproduction in wild female ocelots between 30 and 45 months-of-age. Bragin (1994) reported that reproduction among females in captivity occurred between about 20 months to 15 years and for male captive ocelots between about 22 months to 17 years. Eaton (1977) reported that captive ocelots produce an average of about 1.4 young per litter, but suggested that the average in the wild may be closer to 2.0. Mora et al. (2000) suggested that ocelots in the Lower Rio Grande Valley averaged 1.5 kittens per litter over "the last 10 years" (number of litters not stated). Laack et al. (2005) reported an average of 1.2 kittens per litter for 16 litters born to 12 ocelots in Texas.

Citing "circumstantial evidence," Emmons (1988) suggested that females in Peru produced young "about every other year." However, this estimate did not take into account occasional losses of complete litters, which would expand the interval of successful reproduction. No comparable data are available for Texas. Although an interbirth interval of two years or less suggests that half or more of adult females breed each year, felid populations may contain females that never produce litters (Beier 1993, Logan and Sweanor 2001), and this can have important effects on demography (Beier 1993). There are no published reports of what fraction of adult female ocelots fail to produce litters.

Dispersal - An understanding of movements of ocelots during dispersal is central to evaluating the impact of habitat fragmentation on the population, and evaluating the potential for corridors as a remedy for fragmentation. The literature summarizes only a handful of dispersal events. Tewes (1986) reported that 1 male ocelot apparently dispersed about 13 km before it died of injuries (likely from an automobile collision). The death site was an isolated 150-ha brush patch surrounded by farms and grasslands. Tewes (1986) also reported movements by a young adult female, which probably represented dispersal from LANWR into croplands with small fragments of brushy habitat. Most of her locations were in the remnant shrublands until she was killed by a vehicle. Navarro-Lopez (1985) reported that 2 young adult ocelots dispersed 10 km and 3.5 km. In Tamaulipas, Caso (1994) reported 1 male dispersing 8 km. In Jalisco, Fernandez (2002) reported that 1 male dispersed 23 km from his capture site. Ludlow and Sunquist (1987) reported that dense woody cover was important in facilitating dispersal movements of two subadult male ocelots in Venezuela.

Laack (1991) provided the most detailed information on ocelot dispersal, reporting on dispersal of five male and four female subadult ocelots at LANWR. One ocelot dispersed at 14 months-of-age, 1 at 20 months-of-age, and 5 at 30-35 months-of-age. Two others were captured as dispersers at <23 months-of-age. There was no obvious sex difference in age at dispersal. Only four dispersers (3 M, 1 F) lived to establish home ranges, but one female was still dispersing at the end of the study. Duration of successful dispersal (time elapsed between leaving natal range and establishing an independent home range) was 7 to 9.5 months. The one successful female disperser moved 2.5 km (distance between home range centers) whereas the successful males moved 7 to 9 km. In addition to these dispersers, one subadult female did not disperse but remained in her natal range after reaching adulthood. The extensive explorations of these animals, use of agricultural and other marginal habitat during dispersal, and the dispersal interval suggest that suitable habitat in LANWR was saturated with resident ocelots during this study (Laack 1991).

All dispersers in the Laack (1991) study used narrow (5-100 m) corridors of brush during dispersal. Most of these were along resacas (remnants of former river meanders) and drainage ditches. Each disperser avoided areas occupied by adults, and repeatedly returned to one or more small, semi-isolated patches of thornscrub during dispersal. The established adult home ranges of these same animals did not include these semi-isolated patches. Transient home ranges were often farther from the natal range than the animal's eventual home range. Dispersal from LANWR typically involved movements to and beyond the point that scrub habitat became scarce, use of transient home ranges centered on small scrub patches within agricultural or pasture land, and eventual settling within the source population when a vacancy occurred, or when the animal gained enough mass and experience to displace a resident adult. Dispersal was generally frustrated and circular – similar to that of pumas (*Puma concolor*) in urban southern California (Beier 1995) and panthers (*P. c. coryi*) in south Florida (Maehr et al. 2002). Dispersers may have moved farther if corridors or even stepping stones of suitable habitat were available. Although such dispersal zones are technically "sink habitats" (sites where mortality exceeds reproduction), they also serve as areas free of resident adults where some young ocelots survive as a pool of non-breeding "floaters" that can be an important stabilizing force in population dynamics.

According to Laack (1991), no disperser successfully joined a population outside of LANWR. Subsequent to the thesis of Laack (1991) it was discovered that a male ocelot moved from the Willacy County population to the Arroyo Colorado Unit of TPWD where he was photographed several times between 2000 and 2003. The Arroyo Colorado Unit is located 18 miles southeast of the Yturria Ranch and 5 miles west of LANWR. The male moved back to the Willacy County population where he was photographed in 2005, then back to the Arroyo Colorado Unit and photographed again on January 16, 2006, and then back to the Willacy County population again by March 2006 where he was captured (Tewes et al. 2010, upubl. data). Photographs in 2009 showed the male was still in the area of the Willacy County population (USFWS 2010, unpubl. data). Ocelots from LANWR have been found on the Arroyo Colorado Unit previously; therefore this series of records represents the first documentation of an ocelot moving between the Willacy and Cameron populations in Texas. However, genetic evidence indicates there is a lack of or insufficient gene flow between LANWR and the Willacy-Kenedy populations, and between either of these populations and ocelots in Mexico (Janecka 2006) (see Genetics section).

Although the number of dispersers was small in each study, it appears that ocelots follow the typical felid pattern of obligatory male dispersal but that females can either disperse or remain philopatric depending on density of adult females and perhaps other factors (Logan and Sweanor 2001, Sunquist and Sunquist 2002).

Resacas, rivers, irrigation canals, irrigation drains, natural drainages, shorelines, fencelines, and road verges all provide suitable travel corridors for ocelots, especially as density and percent cover of thornscrub vegetation increase (Tewes et al. 1995). Where a corridor of thornscrub passed through otherwise barren agricultural fields, Tewes et al. (1995) recommended grass-forb strips to enhance eastern cottontail (*Sylvilagus floridanus*) populations. They also recommended managing for wide corridors, dense thornscrub cover, earthen ridges or rows of trees to screen corridors from urban developments, retaining vegetation on at least one side of irrigation canals and drains, and reduced frequency of prescribed fire on margins of farms and ditches.

Survival and mortality - Tewes (1986) reported a survival rate of 71% based on 4 mortalities during 5,022 ocelot-days of monitoring 12 radio-tagged ocelots. Haines et al. (2005b) estimated an annual survival rate at 87% for resident adults and 57% for transient ocelots (post-dispersal and before a stable home range is formed), with small and statistically non-significant differences between males and females. Laack et al. (2005) estimated 68% annual survival for newborn ocelots.

Collisions with vehicles represent the largest known cause of ocelot mortality (45%) in south Texas (Haines et al. 2005b). Aggression and predation by other animals also account for some mortality (Lopez Gonzalez et al. 2002, M. Tewes and L. Laack, unpublished data). Poaching and hunting ocelots for their skins is still a significant source of mortality in some countries (Sunquist and Sunquist 2002). At her study site, which included the Chamela-Cuixmala Biosphere Reserve, Jalisco, Mexico, Fernandez (2002) noted that 3 of 25 ocelots captured were presumably illegally killed as she only found collars that had been cut off the cats.

Competition with other carnivores - In his comments on the draft recovery plan in 1987, H. Quigley observed "The Draft lists the bobcat as both a predator of, and competitor with, the ocelot (p. 16). In the proposed research, why not experiment with a brief removal of bobcats from small areas and monitor the response (if any) in the ocelot population. It's highly unlikely that this would have a negative effect on ocelots in the removal area" (USFWS 1990). Prior to the completion of the recovery plan, no direct evidence of competition with or predation on the ocelot had been published. Since Quigley's suggestion, there has not been an experimental look into meso-predator competition with the ocelot. Emmons (1987) suggested that the ocelot is "in competition for…prey with many snakes, raptors, and other small Carnivora of several families," however. Konecny (1989) suggested that the ocelot in Belize avoided competition with jaguarundi, margay, and tayra through temporal separation and the utilization of different prey. This latter observation seems to be the pattern among small carnivores in the Serengeti (Waser 1980), large carnivores in south Florida (Maehr 1997), and predators in Poland and Belarus (Jedrzejewska and Jedrzejewski 1998). Elsewhere, measurable competitive interactions have been observed between tiger and leopard (*Panthera pardus*) in Nepal (Seidensticker et al. 1990), and between grey fox (*Dusicyon griseus*) and culpeo fox (*Dusicyon culpaeus*) in Chile (Creel et al. 2001). However, in different settings many of these same carnivore assemblages can exhibit a lack of measurable competitive interactions (Johnson et al. 1996).

Emmons' (1987) observation notwithstanding, other studies that have examined ocelot food habits relative to sympatric small and medium-sized carnivores suggest that direct competition with the ocelot is minimal (Brisbal 1986, Konecny 1989, Sunquist et al. 1989). Due to its similar size, relatively aggressive nature, and overlapping distribution, the bobcat (*Lynx rufus*), which does not occur in the tropical systems referenced above, is most likely to compete with the ocelot for food and space in Texas and northern Mexico. Regardless, the current ecological separation may reflect past competition (Connell 1980).

Competition between the ocelot and the bobcat may be minimal because the ocelot is more of a habitat specialist than the bobcat, and it lives in areas of dense cover and high prey populations (Sunquist 2002). However, Tewes and colleagues have examined several scats and found that ocelot and bobcat diets were similar – both consumed primarily cottontails and rodents, with about 30% of food items represented by birds (M. Tewes, Texas A&M at Kingsville, unpubl. data). Perhaps spatial separation and habitat preferences permit such dietary overlap from becoming interference competition. Nonetheless, studies that are targeted at such relationships are warranted. A better understanding of the interactions between the ocelot and competitors will be important in the evaluation of habitat management actions targeted at improving landscape conditions and recovery potential for the species.

Genetics - Small and declining populations, such as the ocelot in Texas, face a variety of genetic challenges. Maintaining overall genetic variability of small populations is vital for persistence, as is preserving natural genetic differentiation of declining populations relative to other populations of the same species. Heterozygosity levels, allelic diversity, gene flow, level of inbreeding, and census and effective population size (N_e), are all important to estimate in managing declining populations. In a phylogeographic context, managers of small populations may need to determine evolutionary significant units (ESUs) and management units (MUs) (Moritz 1994). An ESU is a group that can be thought of as a subspecies-level category and refers to a population that is evolving (based on genetic data) on a unique trajectory relative to other populations of the same species; a MU refers to populations that should be managed as an independent interbreeding group and is usually a smaller subdivision than ESU.

From an evolutionary perspective, resolving the correct taxonomy and genetic lineages for species or populations that are in decline are critical to selecting the most effective management strategy. Genetic diversity estimates are more meaningful when compared to diversity of closely related populations and species. Evolutionary forces such as migration (a potentially strong force for regenerating genetic diversity) can be an important factor in recovering populations. From a genetic perspective, migration can be estimated by examining gene flow among populations. Genetic data on the ocelot are limited to four studies: a species-wide study (Eizirik et al. 1998), one using ocelots in captivity (Newman et al. 1985), and two studies in Texas and northern Mexico (Walker 1997, Janecka 2006).

Species-wide, there are two variable regions and one conserved region contained within the mammalian mitochondrial DNA (mtDNA) Control Region (CR). The CR is a useful genetic marker to resolve evolutionary lineages within a species. Human variable sequence 1 (HVS-1) is the variable region on the 5' portion of the CR, is 600-1000 base pairs in length (including an 81 base pair minisatellite-like repeat, named RS2 for "Repetitive Sequence 2") and was utilized in a species-wide ocelot genetic study. DNA sequencing was performed on the HVS-1 region for ocelots from throughout their range excluding northern Mexico and southern Texas (Eizirik et al. 1998). HVS-1 sequences were generated for 39 ocelots originating from Brazil to southern Mexico and a total of 24 unique sequences (haplotypes) were found. Haplotypes were shared only among ocelots from nearby geographic regions. A phylogenetic analysis of these 24 sequences, using several phylogenetic approaches, revealed 4 phylogeographic groups: 1) southern South America including Brazil (south of the Amazon River) and Bolivia; 2) north-northwest South America including Brazil (north of the Amazon River), Venezuela, Trinidad and Panama; 3) north-northeast South America including French Guyana and northern Brazil; and 4) Central America from southern Mexico to northern Panama. Janecka (2006) compared mtDNA control region sequences from nine ocelots in Texas and Tamaulipas to sequences derived by

Eizirik et al. (1998) from ocelots in southern Mexico, Central America, and South America. The four haplotypes found in the Texas-Tamaulipas ocelot (*L. p. albescens*) as a group were most closely aligned with a haplotype from Nicaragua, followed by haplotypes from southern Mexico and Guatemala.

The ocelot exhibits high CR genetic variability compared to all other mammalian species suggesting a long evolutionary history. This is consistent with previous analyses of captive ocelots that showed high genetic variability based on protein electrophoresis (Newman et al. 1985). A major evolutionary split was observed at the Amazon River, which apparently separates southern South America and north-northwest South America from Central America and north-northeast South America. Another major split was found within northern South America resulting in four distinct geographic regions. High levels of subdivision were found between the four geographic regions as shown by high F_{ST} values (a statistic to indicate levels of subdivision among populations, an F_{ST} of 1 equals complete subdivision or no gene flow, an F_{ST} of zero means complete panmixia) and few estimated migrants. The inferred direction of historical colonization was south to north suggesting that Central America was the most recent area of colonization for the ocelots studied by Eizirik et al. (1998).

The implication of this study for ocelot conservation is the indication of four evolutionary significant units (ESUs, Ryder 1986). As suggested by Eizirik et al. (1998), the Central American and southern South American group of ocelots fulfills the major requirement for ESU designation, that of reciprocal monophyly of mtDNA lineages (Moritz 1994), and should be managed as such. To be conservative, the two groups of northern South American ocelots could provisionally be considered separate ESUs (for a total of 4 ESUs) although additional samples are required to improve the understanding of population structure in that region.

Nuclear and mtDNA markers were also examined to determine if genetic differentiation is present in ocelots from northern Mexico and southern Texas (Walker 1997, Janecka 2006). Target populations included: 1) LANWR in Cameron County; 2) Willacy County including three contiguous ranches; and 3) northern Mexico including four private ranches in Tamaulipas and Vera Cruz, Mexico.

Ten felid nuclear microsatellite markers (highly polymorphic nuclear DNA loci, informative to resolve population-level subdivisions and even distinguish individual ocelots), and 2 regions of mtDNA, a portion of the CR and the Cytochrome B (cytb) gene, were genotyped in 53 ocelots from the 3 populations (Walker 1997). The distribution of samples was 27 from LANWR, 25 from Willacy, and 18 from Mexico. Janecka (2006) expanded on Walker's analyses to include 15 microsatellite loci and 113 samples from the 3 populations (47 from LANWR, 30 from Willacy and 18 from Mexico). Differing levels of genetic variation and genetic subdivision were found in all datasets with Texas populations containing less variation than Mexico. Because ocelot habitat in the U.S. has experienced range reduction and fragmentation, low variability is expected within the Texas populations.

Microsatellite markers generated an average of 2.8 alleles in LANWR, 3.5 alleles in Willacy, and 6.1 alleles in Mexico. Private alleles found across all 10 loci included 2 in LANWR, 3 in Willacy, and 30 in Mexico. Mean heterozygosity followed the same pattern with 0.369 in

LANWR, 0.550 in Willacy, and 0.698 in Mexico. Tests for subdivision indicated greatest differentiation between LANWR and Mexico, moderate differentiation between LANWR and Willacy, and the lowest differentiation between Willacy and Mexico. No interbreeding was detected among the three populations. Migration rates among populations were estimated by Walker (1997) using three algorithms (F_{ST}, Rho_{ST} and private alleles), all of which estimate migration based on alleles in common among populations based on FIS estimates (Mexico = 0.118), Willacy = -0.062, LANWR = -0.063). Haplotype diversity declined from 0.673 in historic Texas populations (1890-1956) to 0.536 by 1984 and 0.000 in 2005 for Willacy-Kenedy (Janecka 2006). Cameron was already at 0.000 by 1986. The current effective breeding sizes of these populations are 5.9 to 14.4 breeders in Cameron and 2.4 to 3.6 breeders in Willacy-Kenedy. It is likely ocelots in the U.S. will begin to manifest problems associated with inbreeding and genetic erosion (Janecka 2006). In theory, a migration rate of 1 ocelot per generation is enough to prevent the 2 populations from diverging completely, whereas, a rate of 10 or more per generation is enough for the 2 populations to appear panmictic, meaning an appearance of random mating between the 2 populations (Mills and Allendorf 1996). Estimated migration rates were: 1) LANWR versus Mexico (0.65, 0.75, 0.47 respectively – for the 3 estimators); 2) LANWR versus Willacy (1.45, 1.47, 0.30 respectively); and 3) Willacy versus Mexico (2.01, 1.29, 0.83 respectively). The private alleles method did not yield significant migration rates (all estimates were less than one). Migration rates barely above "one" were detected between Willacy and the two other populations using the F_{ST} and Rho_{ST} estimators. Phylogenetic relationships (the evolutionary history of a group of organisms) confirmed clustering of individuals by population of origin, with indication of historical connection between Willacy and Mexico. Janecka (2006) used an F_{ST} test for population differentiation and found similar results, with the most differentiation between LANWR and Mexico (0.351) and the least differentiation between Willacy and Mexico (0.139). Janecka (2006) also found that between 1998 and 2005, the heterozygosity of the Willacy-Kenedy population declined 12%. Between 1989 and 2001, the heterozygosity of the Cameron population declined 23.3%. The current loss of genetic variation in the Cameron population is 3.5% per generation.

The mtDNA CR sequence for this study was the 3' variable region, which included the repetitive sequence RS3, and was largely uninformative among these three Texas and Mexico ocelot populations. However, the LANWR population is nearly fixed in repeat length, for the RS3 repeat, indicating a possible bottleneck event in the history of that population. The cyt b gene sequence analysis revealed two unique haplotypes, A and B. Both haplotypes occurred in Mexico and Willacy, whereas, LANWR was fixed for the A haplotype. An analysis of molecular variance (AMOVA) indicated significant subdivision between LANWR and both Mexico and Willacy. Estimates of migrants using cyt b haplotypes were effectively none between LANWR and both Mexico and Willacy with 35 migrants estimated between Mexico and Willacy. This is indicative of historical connection between Mexico and Willacy. The fact that no connection is found between Mexico and LANWR could be an artifact resulting from LANWR's isolation, population reduction and subsequent loss of alleles (thus a loss of shared alleles which affects migration estimates). There are several factors that may explain why little to no migration was detected using microsatellite data, and a reasonably high migration rate (between Willacy and Mexico) was detected from cyt b data. The cyt b gene evolves at a much slower rate than microsatellite regions and is therefore better at resolving older historical events, whereas microsatellites can resolve more recent events. Assuming this is the case, a reasonable conclusion is that the Mexico and Willacy populations were connected historically, but that this connection has recently been lost. Alternately, the high estimate of 35 migrants between Mexico and Willacy may be due to bias of having only 2 cyt b haplotypes.

This study indicates closer genetic relatedness between Willacy and Mexico, than between LANWR and either Willacy or Mexico. Walker (1997) suggested that LANWR and Willacy became isolated from ocelots in Mexico and from each other, and both have lost genetic variation. The LANWR population has probably undergone a more severe bottleneck event causing a more extensive reduction in genetic variation compared to the Willacy population. Because the Willacy population has retained more genetic variation, it has retained evidence of its historical connection with Mexico (as evidenced by the estimated migration rate). The LANWR population, having lost more genetic variation, has by chance lost evidence of its historical connection with Mexico. Thus, the Texas populations are not differentiated from Mexico at the level of being distinct ESUs. Instead, as suggested by Walker (1997), for conservation purposes the two Texas populations should be considered separate MUs (Moritz 1994).

Because Eizirik et al. (1998) did not include individuals from the northern Mexico and southern Texas regions, and different portions of the CR were used for each study, it is unknown if the Texas and northern Mexico ocelots would be most closely related to the Central American ESU. Microsatellite DNA has been collected for the species-wide ocelot samples (E. Eizirik, personal communication), but not yet analyzed. These data would be particularly valuable to the ocelot recovery effort because microsatellite DNA data are also available for the southern Texas/northern Mexico ocelots, and would allow a direct comparison among samples from both studies.

Population Viability Analyses for the Texas/Tamaulipas ocelot

Prior to 2004, no viability analysis had been conducted for the U.S. ocelot population. The Population Viability Analysis (PVA) workshop conducted in conjunction with the April 2004 meeting of the Technical Subcommittee suggested a number of challenges facing the species in Texas (Appendix IV). The ocelot in south Texas appears to be at considerable risk of extinction through intrinsic, stochastic fluctuations in demographic rates that are exacerbated by human activity, especially road construction, in ocelot habitat. The proportion of adult females successfully producing a litter in a given year and additional mortality caused by vehicles are primary factors in determining future population growth. Range increase through habitat improvements may facilitate ocelot population growth and reduced extinction risk. Connecting small, disjunct ocelot populations may provide an additional buffer against extinction risk if: 1) subpopulations are increased in size in a way that approaches viability in the absence of connectivity; 2) dispersal rates – whether natural or artificial – are sufficiently high to maintain a functioning metapopulation; and 3) anthropogenic sources of mortality are reduced to acceptable levels. As few as one or two translocated females every two years may be enough to compensate for the destabilizing effect of stochastic demography operating on this small population. However, it is important that a better understanding of ocelot population size in Tamaulipas be obtained to avoid negative demographic consequences on the source population. Future research should investigate the influences of continued habitat loss in Texas, the impacts of epizootics, and the role of density-dependent survival as population size changes. Haines et al. (2005a) used Population and Habitat Viability Assessment (PHVA) to evaluate four recovery strategies for the Texas/Tamaulipas ocelot and concluded that protection and restoration of habitat had the greatest positive impact on predicted population persistence, followed by linking the two known breeding populations and reduction of road mortality, with supplementation from Tamualipas the least effective strategy. A 2006 PVA predicted a 33% probability that ocelots in southern Texas would become extinct within 50 years under current conditions (Haines et al. 2006).

The first ocelot recovery plan (USFWS 1990) recommended some major demography-related activities for ocelot recovery, namely "determining the precise population sizes and habitat sizes required for viability and the necessary spatial arrangement of habitat, and determining the impact of disease and other factors on the population; increasing ocelot numbers in Texas, in part by protecting at least 20,000 hectares of prime ocelot habitat in Texas (either in a single block or continuous blocks connected by corridors)." The first goal reflected the optimism of the late 1980s about the ability of PVA and PHVA to provide "precise population sizes and habitat sizes" needed for viability. Since 1990, initial exuberance for these tools has been replaced by the view that PVA and PHVA are useful mostly to rank and compare alternative scenarios (Beissinger and Westphal 1998, Ludwig 1999). Another important use of PHVA is to use sensitivity analysis to identify which natural history attributes (e.g., survival rate of a particular age class) and environmental attributes (e.g., lack of corridors) are the crucial determinants of viability.

Habitat Characteristics and Ecosystem

Habitat - The ocelot uses a wide range of habitats throughout its range in the Western Hemisphere (Tewes and Schmidly 1987). Despite this, the species does not appear to be a habitat generalist. Ocelot spatial patterns are strongly linked to dense cover or vegetation, suggesting it uses a fairly narrow range of microhabitats (Emmons 1988, Horne 1998).

In Venezuela, ocelots used palm savanna, sandhills, shrub woodlands, and deciduous or gallery forest (Mondolfi 1986, Ludlow and Sunquist 1987, Sunquist et al. 1989). During diurnal resting periods, ocelots were primarily found in gallery forest. During the night, ocelots used the sandhills more than the diurnal periods, but still predominately occupied the gallery forest. Emmons (1987) found that ocelots in Peru generally avoided open habitats during the day, but sometimes foraged in them at night. Three ocelots used primarily forest or woody communities in Belize (Konecny 1989). A study of three females in the Pantanal Region of Brazil found them primarily in semi-deciduous forest with lesser use of marsh, riverine forest, and grassland (Crawshaw and Quigley 1989).

Lack of suitable habitat has been cited as an important reason for the endangered status of the ocelot in the U.S. (Tewes and Everett 1986, Tewes and Miller 1987). In south Texas, the species occurs predominantly in dense thornscrub communities (Navarro-Lopez 1985, Tewes 1986, Laack 1991). Over 95% of this habitat in the Lower Rio Grande Valley has been altered for agricultural and urban development (Jahrsdoerfer and Leslie 1988). Tewes and Everett (1986) found <1% of south Texas supported the extremely dense thornscrub used by ocelots.

Tewes (1986) found that core areas of ocelot home ranges contained more thornscrub than peripheral areas of their home ranges on LANWR in southern Texas. Laack (1991) also found ocelot use of dense thornscrub on this study site. Caso (1994) found ocelots used primarily forest or woody communities in Tamaulipas, Mexico, and used the open pastures much less often. The pastures that were seldom used by ocelots supported little woody cover and were dominated by bunchgrasses (e.g., guinea grass, *Panicum maximum*). Jackson et al. (2005) suggested that the ocelot in Texas prefers closed canopy over other land cover types, but that areas used by this species tended to consist of more patches with greater edge.

South Texas ocelots apparently prefer shrub communities with >95% canopy cover and avoid areas with intermediate (50-75%) to no canopy cover (Horne 1998). Ocelots did not prefer or avoid communities with 75-95% canopy cover. Other microhabitat features important to ocelots appear to be canopy height (>2.4 m) and vertical cover (89% visual obscurity at 1-2 m). Ground cover at locations used by ocelots was characterized by a high percentage of coarse woody debris (50%) and very little herbaceous ground cover (3%), both consequences of the dense woody canopy (Horne 1998).

Shindle and Tewes (1998) quantified species composition of shrubs in three plant communities used by ocelots. Two of these communities occurred in southern Texas and another was located in northeastern Mexico (Caso 1994). Within the dense thornscrub communities used by ocelots, 45 woody species were found at the LANWR in Cameron County and 28 woody species on the San Francisco Ranch in Willacy County (Shindle and Tewes 1998). The dominant species were granjeno (*Celtis pallida*), crucita (*Eupatorium odoratum*), Berlandier fiddlewood (*Citharexylum berlandieri*), honey mesquite (*Prosopis glandulosa*), and desert olive (*Forestiera angustifolia*) at LANWR, and honey mesquite and snake-eyes (*Phaulothamnus spinescens*) contributed >50% of the total relative cover in Willacy County.

Little is known about ocelot habitat use in Arizona and Sonora; however, Lopez Gonzalez et al. (2003) found that 27 of the 36 records (75%) of ocelots in Sonora were associated with tropical or subtropical habitat, namely subtropical thornscrub, tropical deciduous forest, and tropical thornscrub. Only males (11.1% of the total records) were recorded in temperate oak and pine-oak woodland.

<u>Habitat restoration</u> - Ocelots will use narrow strips of shrub or forests for travel and dispersal (Ludlow and Sunquist 1987, Caso 1994, Tewes et al. 1995). Such corridors can provide critical landscape connectivity, thus they are important aspects of ocelot conservation (Tewes et al. 1995, Tewes and Blanton 1998). Although transportation corridors represent a significant danger, wildlife underpasses at the intersections of roads and linear habitat features used by ocelots can mitigate potential losses (Tewes and Hughes 2001).

Where habitat is degraded and fragmented, as in south Texas, restoration is critical to recovery of the ocelot. The success of ocelot habitat restoration is likely a product of an area's proximity to other ocelot populations, the presence of travel corridors, and its revegetation potential. Ocelots and their habitat are associated with certain soil types in southern Texas (Harveson et al. 2004). Camargo, Laredo, Olmito, and Point Isabel soil series support habitats that have been used by ocelots in greater proportion than they were available (Harveson et al. 2004). This ocelot/soil relationship is probably a consequence of ocelot preference of dense thornscrub cover that appears more frequently on these soil series (Harveson et al. 2004). Planning for revegetation must consider soil types and conditions to properly restore habitat. Soil maps should be useful in identifying potential habitat restoration zones. The selection of specific restoration areas should be a function of their potential to serve as occupied breeding habitat and travel corridors that link currently disjunct tracts of occupied or potential habitat. The re-establishment of thornscrub habitat in appropriate locations and spatial configurations will facilitate ocelot colonization.

Some revegetation techniques have been examined for restoring ocelot habitat, although much information is needed to maximize their efficiency and ultimate use by ocelots. Young and Tewes (1994) evaluated tree shelters, fertilizer, tree branch trimming, and elimination of herbaceous growth to increase and enhance growth of woody seedlings. They concluded that fertilizer, clipping, and weeding did not impact seedling growth or survival. Tree shelters significantly increased survival and growth of tree seedlings, but may not be economically feasible (Young and Tewes 1994). Identification of ocelot cover types, mapping of important corridors and habitat patches, and development of restoration blueprints for the ocelot can be facilitated by the application of remote sensing (e.g., satellite imagery) and geographic information systems (Anderson et al. 1997, Tewes et al. 1999). Such technology would also be helpful in identifying the most likely pathways of dispersal and potential restoration zones needed to link disjunct populations.

Private lands - Much of the area required to provide habitat for viable ocelot populations in Texas and Mexico, and to a lesser extent in Arizona, occurs on private ranches. Landowner anxiety over the implications of having an endangered species on their land may prevent adequate cooperation from this key group of stakeholders. Genho et al. (2003) described the early human settlement patterns in southern Texas and the development of ranching in this area. The region is becoming increasingly urban (Figure 5). Although agriculture is in part a cause of the decline of the ocelot in North America, it is the modern habitats associated with ranches that account for most of the species' current and potential range. South Texas is bordered on the north and on the south by regions of rapid human population growth (Fulbright and Bryant 2003). To the north, the population of the San Antonio area grew 16% from 1990 to 2000 with an estimated population of over 1.5 million people in 1995. The Lower Rio Grande Valley, location of the primary ocelot population in the U.S., has the poorest and most rapidly growing border population of humans in the U.S. (Fulbright and Bryant 2003). The expanding human population, poverty, and high unemployment represent increasing threats to ocelot habitat and ultimate recovery (Figure 6).

The agricultural economy that has supported large south Texas ranches, and that formerly supported the biodiversity of the area, is changing (Potts 2003). These changes, including the subdivision or liquidation of existing ownership patterns, represent challenges to ocelot recovery (Wilkins et al. 2000). Potts (2003) outlined three strategies that landowners use to help increase the profitability of their ranches and reduce the chances that they will have to sell their ranches for economic or tax reasons. The first strategy emphasizes the private markets currently operating for wildlife in southern Texas. Hunting and outdoor recreation potentially contribute more to land value than agriculture or urban development in many south Texas counties (Fulbright and Bryant 2002). The demand for beef has declined and traditional sources of revenue from ranches have been declining or inconsistent since 1980 (Ryne 1998). However, the market for both consumptive and nonconsumptive use of natural resources has grown over the last decade, with recreational uses of private lands providing more value to landowners than cattle ranching alone (Ryne 1998). Undoubtedly, many ranches in Texas would have been subdivided and sold if not for hunting income. This reality is reflected in area land appraisals that value hunting uses above agricultural uses (Potts 2003).

Non-consumptive resource use could be beneficial to the ocelot's future. Ecotourism and bird-watching are growing markets in southern Texas and Arizona. Eubanks and Stoll (1999) found that a person spent an average of $117 per day while participating in the Rio Grande Valley Birding Festival. Economic incentives for private landowners to maintain ocelot habitat on their land, and the promotion of tourist-related activities, could promote recovery of the species. Safe harbor agreements (USFWS 1997a) may provide the security umbrella and incentives sought by private landowners that enable proactive conservation of the ocelot in the U.S.

The second strategy for private lands conservation is government incentives, particularly those for habitat conservation provided by the Farm Bill (Potts 2003). These funds could greatly complement consumptive and non-consumptive wildlife markets.

The third strategy would promote conservation easements and tax incentives that allow landowners to retain ownership and keep the habitat intact without fragmentation (Fulbright and Bryant 2003). One of the primary threats to the continuation of large family ranches in the U.S. is the transfer of property to subsequent generations. Death of a landowner can produce estate taxes that result in the heirs selling property to pay inheritance taxes. Often, the end result is fragmentation of the initial large property into several smaller units with a mosaic of land uses that can have negative effects on biodiversity. Ocelots in the Rio Grande Valley experience several problems that ultimately relate to recent fragmentation events.

Reasons for Listing/Threats

Section 4(a)(1) of the ESA outlines five factors to consider when a species is a candidate for listing as threatened or endangered. The following analysis considers these factors in contributing to the endangered status of the ocelot. Below, we address threats throughout the species range but focus upon the northern units in the borderlands where we have the most information. Additional information about threats to the ocelot south of the United States is provided in Appendix 3.

Factor A - The present or threatened destruction, modification, or curtailment of its habitat or range.

The final rule listing the ocelot as endangered in the U.S. (47 FR 31670, July 21, 1982) stated that the present or threatened destruction, modification, or curtailment of its habitat or range poses the greatest threat to the survival of the ocelot in the U.S. The ocelot's range and distribution in the U.S. have been drastically reduced in the last two centuries. In the mid-1800s ocelots occurred from the Red River in Arkansas south through central and eastern Texas to the Rio Grande (Hall 1981; Navarro et al. 1993). Known ocelot distribution in the U.S. is limited to just a few counties in southernmost Texas (Navarro-Lopez 1985; Tewes and Everett 1986; Laack

1991; Walker 1997; Haines et al. 2006) and two counties in Arizona (Arizona Game and Fish Department 2010, unpubl. data).

Loss of ocelot habitat in the U.S. has been extensive. In the Lower Rio Grande Valley of Texas, over 95% of the dense thornscrub habitat that supports the ocelot has been altered for agricultural and urban development (Jahrsdoerfer and Leslie 1988). In Cameron County, 91% of native woodlands were lost during the mid-1900s, primarily for agricultural use (Tremblay et al. 2005). Currently, rapid population growth in the region is causing agricultural land to be converted to more urban development resulting in land and habitat fragmentation (Wilkins et al. 2000). The human population in the Lower Rio Grande Valley increased 39.8% from 1990 to 2000, compared to an increase of 22.8% in Texas and 13.2% in the U.S. during the same period (Murdock et al. 2002). Population levels in the Lower Rio Grande Valley are projected to increase 130.1 – 181.1% from 2000 to 2040 (Murdock et al. 2002).

Throughout its range, the ocelot has declined in most areas because of illegal hunting and habitat loss (Sunquist and Sunquist 2002). Currently, habitat loss is probably replacing hunting as the major threat (Sunquist and Sunquist 2002). Habitat alteration, particularly from deforestation, agriculture, and ranching, has reduced and fragmented ocelot habitat (Ceballos and Garcia 1995, Lopez Gonzalez et al. 2003). In Central America, less than half of the region retains its original forest cover (Conservation International 2004).

Factor B - Overutilization for commercial, recreational, scientific, or educational purposes.

In the 1960s and early 1970s, ocelot pelts were heavily exploited while some ocelots were imported for the pet trade. Ocelot imports peaked in the U.S. in 1970, with 140,000 skins documented by U.S. Customs (McMahan 1986). Between 1967 and 1973 the commercial export of wildlife was outlawed from many countries in Central and South America (Mann and Plummer 1995). Following these prohibitions, the commercial trade in ocelot skins dropped significantly, and continues to decline (Sunquist and Sunquist 2002). Many European countries banned the import of ocelot skins in 1986. Also, the ocelot was included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora during 1989, an action that outlawed international commerce in skins and live animals (Sunquist and Sunquist 2002). However, implementation of these laws and regulations is not universal. Ocelots are still hunted for their skins, and furs appear regularly in local markets in some countries (Sunquist and Sunquist 2002). Moreover, continued subsistence hunting and poaching of the ocelot are causes of decline or impediments to population recovery (Lopez Gonzalez et al. 2003, Villa Meza et al. 2002, Ceballos and Garcia 1995).

In the U.S., predator control and fur trapping could be a significant source of mortality, and is likely under-reported by trappers. Tewes and Everett (1986) recommended that lethal traps be prohibited in ocelot habitat and daily trap checks should be mandated to reduce deaths and injuries in traps. They also recommended selective methods of predator control, and educating hunters not to shoot ocelots. It is not clear whether these recommendations have been implemented since 1986. The Texas Parks and Wildlife Department has no special restrictions regarding trapping for furbearing animals in or near areas occupied by the ocelot. In Arizona, fur trapping is prohibited on public lands (57% of the state) as well as in most areas where ocelots are most likely to occur.

The USFWS completed a section 7 consultation with the U.S. Department of Agriculture's Animal Damage Control (ADC; now Animal and Plant Health Inspection Services [APHIS]) program regarding the ocelot in 1997 (Starnes 1997), and concluded that after implementing ocelot-protective practices, Wildlife Services' use of leg-hold traps, snares, and M-44s in south Texas was unlikely to jeopardize the continued existence of the species. Although ocelots were regularly taken before the species was listed, no take has been documented from the ADC program since 1983. It is unclear from the biological opinion whether any cats were taken between 1967 and 1983. Major provisions of the protective practices by ADC included using only shooting and cage traps for control of predators in occupied ocelot habitat, and prohibition of neck snares or leg-hold traps larger than #3 within three miles of occupied territories and adjacent travel corridors. The USFWS, in its Conservation Recommendations, asked that ADC personnel alert landowners with whom it conducts control activities of the need to limit lethal activities within ocelot habitat, and that ADC report any non-ADC control activities that fail to comply with state or Federal laws to law enforcement agents.

Factor C - Disease or predation.

Disease can have dramatic impacts on wild populations including those of wild cat species (May 1988, Roelke-Parker et al. 1996). Some of these species are not only endangered, but they serve as "bioaccumulators" at the top of food chains and can be indicators of ecosystem health (Munson and Karesh 2002). Population and ecosystem trends can be derived by studying individuals. For the ocelot this could be done by the opportunistic collection of samples during routine management activities or field studies (Karesh and Cook 1995). Anesthetized animals can easily have blood, hair and fecal samples taken for immediate analysis or archived for future study (Munson and Karesh 2002). Such data are important in understanding major mortality events and in examining long term trends in disease and condition.

There are limited data regarding disease in the ocelot, although several diseases and parasites have been documented. Notoedric mange (*Notoedres cati*) may have killed at least one ocelot in south Texas, and has the potential to cause a mange epizootic in this small population (Pence et al. 1995). Of the 13 ocelots sampled by Mercer et al. (1988), 6 had *Hepatozoon* in the blood, 3 had *Cytauxzoon* in their red blood cells, and all were infested with fleas (*Pulex* sp.) and dog ticks (*Dermacentor variabilis*). An unreported number also had *Amblyomma* ticks. Because Mercer et al. (1988) reported that all ocelots were in "good physical condition," the impact of these parasites on health and survival is not clear. The tapeworm (*Taenia taeniaeformis*) also occurs in ocelots (USFWS 1990). Pence et al. (2003) reported helminths in 100% of 15 adult road-killed ocelots, with low abundances of potentially pathogenic species. Although a single heartworm (*Dirofilaria imitis*) infection may have contributed to the death of one ocelot, Pence et al. (2003) concluded that helminths in general were probably of little significance to the population. Bobcats, feral cats, coyotes, and raccoons provide potential reservoirs for most diseases to which ocelots are susceptible.

Based on blood samples from 20 ocelots, hair samples from 32 ocelots, and tissue samples from 4 ocelots, Mora et al. (2000) reported low concentrations of polychlorinated biphenyls (PCBs), mercury, and DDE (dichloro-diphenyldichloro-ethylene). They concluded that these environmental toxins "currently do not pose any threat to health or survival of the ocelot."

The studies above, while important, have done little to assess the potential for disease and contaminants to affect the ocelot at the population scale. As habitat becomes more fragmented and denatured, interactions with domestic cats, dogs and livestock increase while prey populations and the ability to understand the dynamics of disease decline. Establishing a baseline of "normal" disease dynamics should be part of the basic foundation of ocelot conservation and management. A possible model for the development of such a database can be found in the Jaguar Health Program Manual (Deem and Karesh 2005). This document outlines procedures that must occur in both the field and the laboratory for proper sampling and diagnoses. The protocol in this document would: 1) provide standardized methods to assess the overall health of ocelots in the wild; 2) allow the determination of disease threats (e.g., infectious diseases - intraspecific and conspecific via domestic animals, livestock, other free-ranging felids, prey) and indirect threats (e.g., habitat fragmentation and degradation that may increase disease risks); and 3) facilitate recommendations for the long-term management and conservation of the ocelot.

Artois and Remond (1994) suggested why disease-monitoring in wild populations deserves more emphasis in field studies:

1. Disease can have a devastating impact on small populations. A proper disease monitoring program for small populations allows the best chance for successful intervention.
2. Even for larger populations, disease can be a major environmental influence. Infectious disease can affect populations in a manner independent of host density such that sparse and widely dispersed populations are nonetheless at risk.
3. Biological samples promote clinical and ecological knowledge of the circulation of pathogens.

Aggression and predation by other animals also account for some ocelot mortality. Ocelots were killed by other ocelots (2), domestic dogs (3), coyotes (1), unknown mammals (2), and a diamondback rattlesnake (1) (M. Tewes and L. Laack, unpublished data). The remains of two ocelots were found in ponds occupied by American alligators (*Alligator mississippiensis*). Pumas killed three radio-collared ocelots (one male and two females) between 1994 and 2001 in the Chamela-Cuixmala Biosphere Reserve (Lopez Gonzalez et al. 2002).

Factor D - The inadequacy of existing regulatory mechanisms.

The ocelot and some of its habitat is protected by the ESA in the United States. In Texas, most of the remaining ocelot habitat is on private lands. Due to landowner anxiety about the potential implications of having an endangered species on their property, much of the remaining habitat has not been surveyed. It is also mostly unprotected from development. In Arizona, Commission Order 14, an active law under Title 17, prohibits the take of ocelots. Arizona Game and Fish Department regulation, R12-4-404, regarding the taking of live wildlife under a hunting or fishing license, prohibits live possession of ocelots and other species. In addition, the Arizona Game and Fish Department has authority over scientific collection permits, and can approve, modify, or deny permit applications for ocelot research. In Mexico, although the ocelot was formerly an important game species, hunting was banned in 1986 and now is considered endangered by Mexican Law (NOM-059-ECOL-2001)(Lopez Gonzalez et al. 2003, Caso 1994). Illegal hunting of the species appears to continue in many rural areas of Mexico.

Throughout Central and South America, poverty, ineffective law enforcement, and lack of incentives that support conservation, are root causes of poaching, logging, and human encroachment that threaten the ocelot in many parts of its range (Conservation International 2004). Hunting is still allowed in Peru, in addition to Ecuador, El Salvador, and Guyana offering no legal protection for the ocelot (Fuller et al. 1987).

The U.S. has little authority to implement actions needed to recover species outside its borders, especially when recovery requires the employment of laws and regulations. In many of the foreign countries in the range of the ocelot, key threats include the killing of ocelots and destruction of their habitat. The powers that the USFWS can employ in this regard are limited to prohibiting unauthorized importation of listed species into the U.S., prohibiting persons subject to U.S. jurisdiction from engaging in commercial transportation or sale of listed species in foreign commerce, and assisting foreign entities with education, outreach, and other aspects of conservation through our authorities in section 8 of the ESA. The "take" prohibitions of section 9 of the ESA only apply within the U.S., within the territorial seas of the U.S., and on the high seas. They do not apply in the foreign countries where the majority of ocelots are actually found. Section 7 of the ESA, which provides for all Federal agencies to utilize their authorities to carry out programs for the conservation of the species, and to insure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of listed species or adversely modify its critical habitat, is the primary tool within the ESA to address conflict with development or construction. The USFWS has no section 7 authority outside the boundaries of the U.S. Within the U.S., section 7 authority has been waived in a specific instance regarding threats to the jaguar and construction of the border barrier pursuant to the Real ID Act (P.L. 109-13; for more details see below in Factor E).

Factor E - Other natural or anthropogenic factors affecting its continued existence.

Roads – Roads have two documented impacts, and a third potential impact, on ocelot populations. First, collisions with motor vehicles in Texas appear to be the leading cause of known ocelot mortality (Tewes 1986, Tuovila 1999) and accounted for 45% of deaths of 80 radio-tagged ocelots (Haines et al. 2005*b*) between 1983 and 2002. Twenty-six of 61 ocelot deaths between 1983 and 2004 were caused by vehicle collisions (Laack and Tewes unpublished data) in Texas. While some underpasses and culverts have been installed for ocelots in Texas, more are needed and correct placement is critical for them to be used by ocelots as travel corridors (Tuovila 1999, Cain 1999). Second, roads can decrease the probability of successful dispersal between patches of suitable habitat, thus increasing demographic and genetic isolation of populations. Third, to the extent that ocelots might avoid areas of high road density, some otherwise suitable habitats may not be occupied by ocelots. Such avoidance of otherwise suitable habitat has been reported for wolves (*Canis lupus* - Theil 1985, Mech et al. 1988) and black bears (*Ursus americanus* - Brody and Pelton 1989, Orlando 2003). Recovery efforts would benefit from information on how ocelots locate home ranges relative to roads, or use culverts or underpasses to negotiate roads. Additionally, roads in ocelot habitat facilitate increased human presence which may lead to increased poaching of ocelots and their prey, as well as increased disturbance to ocelots.

Border issues - Recent actions such as the signing of the North America Free Trade Act in 1994, increased border monitoring associated with illegal immigration starting in 1998, and homeland security since 2001 have impacted current and future ocelot recovery efforts. Borderland factors that impact ocelots include urbanization (brush clearing for buildings, sewage dumped into Rio Grande River and tributaries, and road construction and maintenance), water development (brush clearing, channeling, draining), agriculture (brush clearing, pesticide run-off), U.S. Border Patrol Operations (lighting; road construction and maintenance; tower construction and maintenance; brush clearing; human activity, including on and off-road vehicular activity) (Jahrsdorfer and Leslie 1988, Lorey 1999), and the construction of fences to prevent illegal immigration into the U.S. (Defenders of Wildlife www.defenders.org/border/border-report.pdf). Also, there are nine existing international bridges, two additional bridges under construction, and three more bridges under consideration within Cameron, Hidalgo, and Starr Counties in Texas that act as east-west barriers for ocelot movement.

In 2006, Congress passed the Secure Fence Act, mandating that 700 miles of physical fencing be installed along the U.S./Mexico border by the end of 2008. The Secure Fence Act also gave the Secretary of the Department of Homeland Security the ability to waive any law or treaty to erect the fence, including environmental laws such as the National Environmental Policy Act, Clean Water and Clean Air Acts, Refuge Improvement Act, Migratory Bird Treaty Act, and Endangered Species Act. On April 1, 2008, Department of Homeland Security Secretary Michael Chertoff invoked his ability to waive these laws and continued construction without compliance.

Approximately, 70 miles of pedestrian fence in 21 sections have been proposed in the Lower Rio Grande Valley and will directly and indirectly impact the Lower Rio Grande Valley NWR, TPWD, The Nature Conservancy (TNC), and Audubon Sabel Palm Sanctuary lands. Of these 70 miles, 22 miles of flood control wall/fence have been proposed in Hidalgo County that will impede north-south connectivity for the ocelot. Construction on the flood control wall/fence in Hidalgo County began on July 21, 2008.

In Arizona, the border from the Tohono O'odham Nation to the Arizona-New Mexico border is a mix of pedestrian fence (not permeable to ocelots), vehicle fence (fence designed to prevent vehicle but not pedestrian entry; it is generally permeable enough to allow for the passage of ocelots), legacy (older) pedestrian and vehicle fence, and unfenced segments. Pedestrian fence exists from Nogales east to the boundary of the Coronado National Forest and from Douglas west through the Coronado National Memorial. Most of the Coronado National Forest, which lies between Nogales and Naco, is bordered by vehicle fence, but the steepest areas are unfenced. The San Rafael Valley is bordered by vehicle fence. Vehicle fence also exists from two miles west of the Arizona/New Mexico border west to the terminus of the pedestrian fence on the east side of Douglas. The Arizona Ecological Services Field Office continues to recommend to U.S. Customs and Border Protection (CBP) that openings large enough to allow for the passage of ocelots be installed in pedestrian fence in Arizona. Impenetrable fences are and will continue to be barriers to non-volant species such as the ocelot (Bies 2007). Specific impacts to the ocelot are the losses of habitat and travel corridors necessary for population maintenance (Tewes et al. 1995). In addition, opportunities for recreating landscape connectivity across this international border will be much more difficult in the future. Thus, ocelot recovery in the U.S. will be greatly hindered as they become more genetically and demographically isolated from the much larger Mexican population.

Another factor affecting the continued existence of ocelots in the U.S. is the increased pressure by the CBP on traditionally used points of entry by undocumented immigrants which shifts immigration into the most inaccessible zones where impacts on the ocelot and other species may be high (Ackerman 1998, Klein 2000). For example, after implementing Operation Gatekeeper near San Diego in 1994, apprehension of undocumented immigrants dropped 46% in California whereas apprehensions increased 88% in Arizona and Texas where intense monitoring efforts were not implemented (Ackerman 1998). With the drafting of the *Programmatic Environmental Impact Statement for US Border Patrol Activities within the Border Areas of the Tucson and Yuma Sectors, AZ* (Immigration and Naturalization Service 2002a), and the *Final Biological Assessment for Impacts to Endangered and Threatened Species Relative to Operation Rio Grande in Starr, Hidalgo, and Cameron Counties, Texas* (Immigration and Naturalization Service 2002b), border security actions will need to be addressed as they relate to ocelot recovery and maintaining connectivity with Mexican populations. Actions on behalf of the ocelot will need to consider the cumulative impacts of fencing, lighting, highway traffic, and habitat avoidance due to human activities.

Genetics - Small and declining populations, such as the ocelot in Texas, face a variety of genetic challenges. Maintaining overall genetic variability of small populations is vital for persistence, as is preserving natural genetic differentiation of declining populations relative to other populations of the same species. Heterozygosity levels, allelic diversity, gene flow, level of inbreeding, and census and effective population sizes (N_e), are all important to estimate in managing declining populations.

When managing small isolated populations, genetic health can be maintained most effectively by connecting them either with landscape connections or through translocations. In Texas, the LANWR population currently has the greatest need for linkage to other ocelot populations. If translocations are pursued as a recovery action, it will be important to monitor the genetic characteristics of the source and recipient populations prior to each translocation event. This should be followed by monitoring the recipient population after each translocation event.

Miscellaneous - Agricultural pesticides and herbicides may also have negative impacts on the ocelot. While common contaminants have appeared in ocelots, they occur at low levels and do not seem to be a major problem (Mora et al. 2000). On the other hand, impacts to potential prey have been observed. For example, in the Lower Rio Grande Valley of Texas the number of amphibian and reptile species has been reduced by 65% and 51%, respectively, perhaps the result of decreased prey availability (Jahrsdorfer and Leslie 1988). Continued monitoring for impacts to ocelots will be needed. Recently Seth Riley and Ray Sauvajot (National Park Service, personal communication) documented 80% of bobcats and half the mountain lions tested in the Santa Monica Mountains of California had secondary poisoning from anticoagulant rodenticides. In 2002-2003, survival rates of both felids dropped by about 50% due to deaths attributable to an interaction between notoedric mange and these secondary poisons.

In 1991, an ocelot was poisoned by a hunter who was trying to rid his deer feeder of raccoons. The hunter apparently laced chicken meat with aldicarb and threw it in the brush, indiscriminately poisoning all carnivores that ate the meat (Laack, unpublished data). In 1999, an archery hunter misidentified an ocelot as a bobcat and killed it (M. Fain, Texas Parks and Wildlife, retired, personal communication).

Climate change – According to the Intergovernmental Panel on Climate Change (IPCC) (2007), "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1,300 years (IPCC 2007). It is very likely that over the past 50 years cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). It is likely that heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007).

The IPCC (2007) predicts that changes in the global climate system during the 21st century are very likely to be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C (0.4°F) per decade is projected (IPCC 2007). Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007). Various emission scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6°C to 4.0°C (1.1°F to 7.2°F) with the greatest warming expected over land (IPCC 2007). Localized projections suggest the southwestern U.S. may experience the greatest temperature increase of any area in the lower 48 states (IPCC 2007). The IPCC says it is very likely hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007). There is also high confidence that many semi-arid areas like the western U.S. will suffer a decrease in water resources due to climate change (IPCC 2007).

We do not know whether the changes that have already occurred have affected ocelot populations or distribution, nor can we predict how the species will be affected by the type and degree of climate changes forecast by a range of models. But, ongoing and future changes in climate have the potential to adversely affect the ocelot within the next 50 to 100 years. Stochastic threats such as drought and wildfires in ocelot habitat may make this species especially vulnerable. Monitoring of habitat and populations will be needed to address the potential threat of climate change. Therefore, we will continue to monitor the species and its habitat, and will adapt our recovery and management strategies when necessary to address the changing conditions.

Biological Constraints to Ocelot Recovery

Little is known about biological constraints to ocelot recovery outside of the borderlands of the U.S. and Mexico. It is likely, however, that some of the constraints exhibited in the borderlands at the northern extremity of the ocelot's range, are of less importance towards the core of its range. Within the borderlands, the ocelot is a tropical felid residing within the subtropics (Thornthwaite 1948, Lonard and Judd 1985). Extreme cold temperatures may limit ocelot reproduction and survival more so than other native cat species (i.e., bobcat with a more widespread distribution in the U.S; Sunquist & Sunquist 2002). However, the ocelot as well as the jaguar (*Panthera onca*) (both felids that range throughout the neotropics [Sunquist and Sunquist 2002]) once were found in eastern and central Texas during the pre-settlement era (Bailey 1905), but they may not have been in great abundance. Navarro-Lopez (1985) suggested that habitat around riparian corridors allowed ocelots to move northward. However, they suggested that ocelot range has been shrinking southward since at least the Pleistocene due to a cooler climate, with few recent records of the ocelot north of 30º N latitude.

The ocelot is a habitat specialist preferring thick thornscrub habitat within its fragmented range in southern Texas (Navarro-Lopez 1985, Tewes 1986, Laack 1991, Horne 1998, Harveson et al. 2004). Its recovery in Texas will depend on the protection and reestablishment of thick thornscrub habitat as core habitat and landscape linkages among population segments (Tewes and Everett 1986, Tewes and Miller 1987). Such connectivity may permit the expansion of ocelot numbers from areas such as LANWR (Laack 1991). Other biological constraints include low fecundity compared to the bobcat and mountain lion (*Puma concolor*)(Cisin 1967, Eaton 1977, Fagan and Wiley 1978, Mellen 1989), species that range more widely in North America. Low fecundity decreases the intrinsic growth rate so populations will take longer to expand. However, the ocelot's short-interparturition periods and ability to breed year-round may compensate for low fecundity in tropical environments (Eaton 1977, Laack et al. 2005). Another potential biological constraint may be a low percentage of breeding females. Emmons (1988) believed that female ocelots breed only every other year as an adaptation to low expected rates of energy acquisition. However, both captive (Eaton 1977) and wild ocelots (Laack et al. 2005) can breed every year.

Short-interparturition periods, the ability to breed year round, concentration of resources on few young and the preference for thick canopy cover for den sites (Laack et al. 2005) may be better suited for species in tropical environments. Similar reproductive adaptations are found in other small to medium-sized Neotropical cats such as the oncilla and margay (Fagan and Wiley 1974, Quillen 1981, Widholzer et al. 1981, Eaton 1984). However, these adaptations may not be advantageous in climates that are more temperate. The Lower Rio Grande Valley and Gulf Coast of Texas are in a sub-tropical region – some years are more tropical (i.e., warm temperatures year-round, moist conditions) than other years (i.e., cold winters, drought conditions) (Thornthwaite 1948, Lonard et al. 1991). In Arizona and Sonoram, Lopez Gonzalez et al. (2003) found that ocelots were associated with tropical or subtropical habitat, namely subtropical thornscrub, tropical deciduous forest, and tropical thornscrub. Ocelots may be constrained by their reproductive ecology and preference for dense canopy cover, and their level of fitness may not be as high within subtropical regions as in more tropical areas. These variables should be considered when developing recovery strategies and defining delisting parameters for ocelots in the U.S.

The possibility for competition for space and food resources may exist with other native cat species and possibly the coyote. The potential for competition is discussed elsewhere in this document, but is likely more of an issue for a species such as the ocelot that exists at the limits of its distribution where a variety of factors may interact synergistically to limit fecundity, survival, and the potential for range expansion.

CAPTIVE BREEDING AND MANAGEMENT

The first ocelot recovery plan (USFWS 1990) did not describe a role for breeding and management of captive wild ocelots (*L. pardalis albescens*). However, the authors did consider the need in the step-down outline (15) to "Develop contingency plans for captive maintenance of unplanned ocelot acquisitions." To that end, USFWS developed a verbal agreement with the Gladys Porter Zoo in Brownsville, Texas to care for injured or sick ocelots recovered from LANWR (L. Laack personal communication 2003). The development of a more formal agreement that covers the welfare of sick, injured, or otherwise obtained wild ocelots is warranted.

Since the publication of the first recovery plan in 1990, much work and research has been done on ocelot biology, husbandry, and breeding strategies in captivity. In Texas, member institutions of the American Zoo and Aquarium Association (now the Association of Zoos and Aquariums) formed the Texas Ocelot Research and Conservation Consortium (Kaemmerer et al. 1996, Kaemmerer 1999). Its primary purpose was to facilitate research on captive generic (i.e., of unknown geographic origin) ocelots based on recommendations from experts who identified topics that could not be adequately addressed in the field, but could be done in captivity. Studies included physiology (Weller and Bennett 2001), responses to olfactory cues (Cooke 1999, Rypkema 2000), nutrition and digestion of prey, and behavioral ontogeny of kittens and mother-kitten interactions (C. Bennett, Dallas Zoo, personal communication).

Studies on basic reproductive function and enhancement through assisted reproductive technologies have occurred (Morais et al. 1996, Moreira et al. 2001, Swanson 2002). Collecting and storing ocelot semen and embryos, examining nutrition and stress, understanding captive husbandry factors that affect sperm quality (Swanson et al. 2003), artificial insemination (Swanson et al. 1996), and *in vitro* reproduction (Swanson 2002) have taken place. In 2000, an ocelot embryo was successfully transplanted into an unrelated female ocelot that subsequently gave birth (Swanson 2001). Ongoing studies include transferring frozen embryos from captive ocelots in Brazil (*L. pardalis mitis*) to generic captive ocelots in North America (W. Swanson, Cincinnati Zoo and Botanical Gardens, personal communication).

There are records of ocelots in captivity since 1891 (Bragin 1994). The first studbook for North America was developed under the auspices of the American Zoo and Aquarium Association (AZA), and recorded in the International Species Inventory System (ISIS) (Bragin 1994). This is a listing of all ISIS ocelots, living and deceased, their origin, if known, their dams and sires, if known, when and to where they were transferred, and their last captive location. Other individual information is often recorded including identifying marks, rearing history, medical conditions, geographic origin, etc. Changes in the captive population through births, deaths, imports or exports are tracked through updated studbooks (Bragin 2003). There are no ocelots in the studbook identified as *L. p. albescens* or *L. p. sonoriensis.* Beginning in 1997 a population management master plan recommended potential reproductive pairings in the population to improve genetic representation of founder lines and demographic structure; this has been done regularly as population changes have occurred (Bragin et al. 2001)

Under the conservation and science branch of the AZA, the Felid Taxon Advisory Group (Felid TAG) serves as an umbrella group to advise, monitor, and represent all activities performed through felid studbooks, Species Survival Plan (SSP) committees, and specialized felid task force groups. When a felid species, which has a viable captive population being tracked through a studbook, is also threatened or endangered in the wild, has significant educational relevance, and has the potential to be an umbrella species for particular ecosystems, the Felid TAG may develop a Species Survival Plan (SSP)(Wiese and Hutchins 1994). The SSP has a steering committee elected by representatives from every AZA institution holding that species. The steering committee is responsible for setting goals for captive population structure and growth, initiatives to educate the public, research needs, and initiatives to enhance and promote conservation in the wild. To further conserve the species, the SSP collaborates with governmental organizations including the USFWS, as well as non-governmental organizations.

The Ocelot SSP, formed in 2001, has a goal in North America of supporting the efforts of the USFWS Ocelot Recovery Team and Recovery Plan. "The SSP supports the efforts of the U.S. Fish and Wildlife Endangered Ocelot Recovery Team and the Ocelot Recovery Plan, both of which impact ocelot conservation efforts in N. America" (Kaemmerer et al. 2004). The Felid TAG directed that the future North American captive population should represent the Brazilian subspecies *L. p. mitis* so that it eventually replaces the current mostly generic population. As such, one of the SSP's primary goals has been to collaborate with Brazilian governmental and non-governmental organizations to fund six projects through the formation and administration of the Brazilian Ocelot Consortium. These include publication of felid studbooks and husbandry manuals, captive propagation and management of Brazilian ocelots, professional training of Brazilian zoo staff and scientists, maintenance of a biological resource bank for Brazilian felids, environmental education, and habitat restoration. In return, 10 pairs of unrelated Brazilian ocelots are to be imported over a 5-year period to form the nucleus of the future North American captive population (Swanson 2003).

One of several tools for conservation of an endangered species is the creation of a captive population to serve as "insurance" in the event the wild population suffers catastrophic losses, as well as to facilitate research that could not be done in the wild (Wiese and Hutchins 1994). Some captive breeding programs and management plans developed from agreements among SSPs (e.g., black-footed ferret, red wolf), USFWS, and other agencies have provided valuable information through research, as well as directly augmenting wild populations through release of captive animals. With the vast experience of captive husbandry, education, and research, the AZA and Ocelot SSP can assist in the recovery of the Texas/Tamaulipian ocelot, *L. p. albescens* and/or the Arizona/Sonoran ocelot, *L. p. sonoriensis.* The potential and need for such assistance should be examined for the ocelot.

PUBLIC EDUCATION

Because ocelot recovery in Texas/Tamalipas and Arizona/Sonora is a bi-national effort, it is important for education to address school systems and regional cultures specific to northern Mexico, south Texas, and other areas where ocelots occur or may be introduced.

The Dallas Zoo's Conservation Education and Science Department has developed an interactive bilingual web-based program about the ocelot, entitled "The Ocelot Experience," which may be accessed at www.dallaszooed.com. It was designed to be useful for students in both Texas and Mexico. It can also be used as a resource for developing a more comprehensive conservation education program (e.g., adopt a school programs, bilingual training, bilingual coloring books, curricula that can be adapted by teachers from either country, a mechanism to address the digital divide, etc.), and can provide connections between the citizens of the United States and Mexico by focusing on species that concern both countries.

This website adds an educational component to ocelot conservation and was created to help raise the awareness of the species' endangered status, and to encourage its protection. The targeted audience for the website is 4^{th} through 6^{th} grade students with either English or Spanish as the primary language; the opening page allows viewers to choose the language. It contains basic information on the natural history and conservation status of the ocelot, as well as an interactive demonstration of field research. Interactive components include a matching game and a section allowing viewers to paint line drawings of ocelots and other wildlife in assorted colors and then print them. The website encourages students to become field researchers and to utilize math, science, reading, and geography skills. The education components were designed to meet Texas State Education and National Science standards. The most recent update of the program provides a mechanism to evaluate its effectiveness. To date, this is the only internationally accessible public education program with the ocelot as its primary focus.

Friends of Laguna Atascosa Wildlife Refuge, a nonprofit group, has created the Adopt-an-Ocelot program. This program allows supporters to symbolically 'adopt' an ocelot by contributing to a fund to be used for education, research, and habitat restoration for the ocelot. Supporters receive educational materials about ocelot ecology, the species' conservation challenges, and details of the lives of individual ocelots found at LANWR. To date the program has gained supporters from throughout the United States and Canada.

LANWR, Friends of Laguna Atascosa Wildlife Refuge, and Valley Morning Star host an annual Ocelot Conservation Festival in Harlingen, Texas. This outreach and educational event raises awareness about the ocelot and its ecology and promotes ocelot and habitat conservation in local communities. The event includes captive-reared ocelots, live wildlife exhibits, educational nature programs, and family-oriented nature activities. Proceeds from the event go to the Adopt-an-Ocelot program of the Friends of Laguna Atascosa Wildlife Refuge.

In Sonora, Mexico, Naturalia does environmental education and outreach on spotted cats, the Northern Jaguar Project runs a photo incentive program for cats, and the National Commission on Natural Protected Areas does a lot of public outreach.

CONSERVATION ACTIONS TO DATE

While loss and fragmentation of habitat adversely affect ocelot populations, a number of conservation actions have occurred which are improving habitat conditions for the species in Texas and northern Mexico:

- The Laguna Atascosa National Wildlife Refuge, located in Cameron and Willacy Counties, Texas, has grown from 18,287 ha in 1999 to 35,952 ha in 2010. LANWR has a Refuge Expansion Plan (USFWS 1999) which approves the acquisition of up to 43,758 ha. LANWR and surrounding lands within 15 km of LANWR contain 7,500 ha of dense thornscrub habitat (Haines et al. 2005a). Recent additions to the refuge provide protected habitat and buffers from incompatible land uses.
- The Lower Rio Grande Valley National Wildlife Refuge (LRGVNWR), located in Starr, Hidalgo, Willacy, and Cameron Counties, Texas has grown from 5,526 ha in 1984 to 32,045 ha in 2010. The LRGVNWR Land Protection Plan (USFWS 1984) targets the acquisition of up to 53,621 ha. Several areas of the LRGVNWR have habitat suitable for ocelots, including the area around the Salt Lakes in Hidalgo and Willacy Counties and parts of eastern Cameron County. LRGVNWR also has an easement with a private landowner in Willacy County that is occupied by ocelots.
- Both LANWR and LRGVNWR are restoring agricultural land to native thornscrub. LRGVNWR reforests about 300 ha/year through cooperative farming agreements (USFWS 1997c). LANWR set aside about 400 ha of farmland in the 1980s where the planting of native shrubs and natural plant colonization from surrounding brushland occurred. These tracts are being utilized by foraging ocelots. LANWR is also restoring an additional 162 ha of thornscrub through a cooperative farming agreement.
- A separate but parallel habitat restoration program, operated by the STRC, the Burned Area Emergency Response (BAER) provides funding for restoration of areas impacted by wildfires. From 2006 to 2009, 4 sites totaling 172 acres were treated with herbicide for invasive grass control and replanted with native brush species. This program currently has more than 570 acres in approved/funded BAER plans for restoration in the next 3 years. An additional 10 acres of retired oil and gas pads have been restored to native brushlands.
- The Nature Conservancy (TNC) has acquired thousands of acres in land to help protect ocelot habitat and create corridors between existing habitats. On January 31, 2008, TNC purchased a conservation easement of 697 acres to further protect the Willacy County population and other wildlife. On December 14, 2009, TNC purchased an additional 1,300-acre conservation easement for the protection of wildlife corridors in south Texas and to help in the recovery of ocelots. These TNC easements compliment the adjacent 472 acres under conservation easement with USFWS.
- The National Commission on Natural Protected Areas (known by its Spanish acronym CONANP) announced in April 2005 that a new Flora and Fauna Protected Area, Laguna Madre and Delta del Rio Bravo, was created in Tamaulipas, Mexico. It covers 572,808 ha of the Laguna Madre and adjoining coastline and will protect ocelot habitat that occurs in the region.
- In 2003, the Mexican non-profit group, Naturalia, purchased a 4,047 ha ranch in northern Sonora to protect the jaguars and its habitat. Ocelots also occur there and will benefit

from this protection. In 2008, they purchased an additional 14,164 ha, making what is now called the Northern Jaguar Reserve a total of 18,211 ha.

- The Rancho El Aribabi in northern Sonora, where ocelots have been documented recently, is seeking to be recognized as a national reserve.
- The USFWS approved a Safe Harbor Agreement (SHA) developed by the Environmental Defense Fund for the ocelot in 2006. The SHA is designed to encourage restoration of private lands to provide suitable habitat for the ocelot and to provide connectivity between areas currently occupied by ocelot. So far 4 landowners in south Texas have enrolled for a total of 15,800 acres. Two landowners in Tamaulipas have enrolled for a total of 3,580 acres in Mexico.
- In 2005, a new USDA-Natural Resources Conservation Service standard was written which describes how to establish thornscrub on cropland for the benefit of the ocelot (http://efotg.nrcs.usda.gov/references/public/TX/RestorationofDecliningHabitatsSpecification10-11-05.pdf). This standard is being employed under the Farm Services Agency practice cp4d (www.fsa.usda.gov/Internet/FSA_File/2-crp.pdf). This program provides a financial incentive for landowners to restore ocelot habitat on their property.
- The Texas Department of Transportation has installed a number of highway underpasses for ocelots, including along Highways 106 and 48 in Cameron County, Texas. Both roads run through or adjacent to LANWR, and ocelot mortalities due to vehicle collisions have been documented on both roads in the past.

Part II

RECOVERY

2.1 Goals, Objectives, and Criteria

2.1.1. Recovery Goal

The goal for this plan is to restore and protect the ocelot and its habitat so that its long-term survival is secured and it can be considered for removal from the list of threatened and endangered species (delisted).

As a species that is listed throughout its range (21 countries in addition to the United States), the ocelot presents a significant challenge for recovery planning. Our knowledge regarding the status of the species in much of its range is limited, and the USFWS and its partners lack the resources and authority to coordinate large scale international research and recovery for the entire species. However, we can establish the framework to better understand the status and conservation needs of ocelots for recovery throughout their range. We can cooperate with our partners in the border states of Mexico to focus efforts within our respective jurisdictions to conserve and recover ocelot populations in the northern limits of the species' range. We can establish specific criteria for recovery, and actions that, if implemented, will conserve viable ocelot populations in the borderlands (Arizona, Sonora, Tamaulipas, and Texas). If these criteria are met, we believe that it may be feasible and appropriate to consider downlisting or delisting these populations as Distinct Population Segment (DPS) or as separate subspecies. Further details regarding this consideration are at the end of the following section.

2.1.2 Recovery Strategy

Our approach in this revision to the ocelot portion of the 1990 "endangered cats" recovery plan is as follows:

- To summarize what is known about the status of the ocelot throughout its range, and identify primary information gaps and broad actions necessary to address conservation of the species outside of the U.S. and in the bordering states of Mexico.

- To address in significant detail the actions necessary to conserve the existing and highly imperiled breeding populations in Texas and their source population across the border in Tamaulipas, Mexico.

- To address the status of the existing population in Arizona and Sonora, Mexico, and identify the actions necessary to understand its status and to conserve the population through cooperative efforts in the borderlands of Arizona and Sonora.

While we consider the ocelot throughout its range, we focus the details of this recovery plan on two management units, the Texas/Tamaulipas Management Unit (TTMU) and the Arizona/Sonora Management Unit (ASMU). We recognize the conservation needs and challenges facing the ocelot elsewhere in its range, but there are compelling circumstances that dictate this focus. The USFWS has little authority to implement actions needed to recover species outside the U.S. borders. The management and recovery of listed species outside the U.S. borders, including the ocelot, is primarily the responsibility of the countries in which the species occur, with the help of available technical and monetary assistance from the U.S. Thus, it is appropriate to focus our efforts and resources on conservation of the ocelot in the northern part of its range as our contribution toward an international effort to conserve and recover the ocelot rangewide.

Recovery management units are subunits of the listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Management units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. Establishing management units is a useful tool for species occurring across wide ranges with multiple populations, varying ecological pressures, or different threats in different parts of their range. Management units are primarily delineated on a biological basis; however, boundaries may be modified to reflect differing management regimes. Management units are not necessarily self-sustaining viable units on their own, but instead need to be collectively recovered to ensure recovery of the entire listed entity.

Texas supports an isolated, highly imperiled population that once was demographically linked to the State of Tamaulipas. The TTMU is a logical management unit because: 1) it encompasses the current known range of the subspecies (*L. p. albescens*); 2) the U.S. population was historically contiguous with a larger regional population across the Rio Grande River; 3) it has distinct habitat conditions that occur nowhere else in the species' range; 4) peripheral populations such as these are important genetic resources; and 5) there are established international cooperative efforts on behalf of the species in this area that are currently underway. Further, peripheral populations may be beneficial to the protection of evolutionary processes and the environmental systems that are likely to generate future evolutionary diversity (Lesica and Allendorf 1995). This may be particulary important considering the potential threats of global climate change (see Factor E above).

The ASMU is similarly logical, although less is known about this population. Although we lack any evidence of an historic breeding population in the Arizona, it is clear that the subspecies *(L. p. sonoriensis*) occurs in the state at least as dispersing individuals. Due to unique habitat that occurs in northern Sonora and southern Arizona, the ASMU also represents a distributional extreme and the important genetic/adaptive resources that can characterize peripheral populations (Lomolino and Channell 1995). Thus, we have defined the boundaries of these two management units as the original subspecies' ranges as described by Hall (1981).

<u>TTMU</u>: Habitat loss and the fragmentation of remaining suitable habitat is clearly the greatest threat to the persistence and recovery of the ocelot in this borderland population. Whereas a variety of recovery actions are needed to fully address the conservation challenges of the ocelot, the most immediate concerns relate to the negative consequences of habitat limitations in Texas and loss of connectivity with ocelots in Tamaulipas. Recent records of the ocelot are known only for five south Texas counties, a tiny fraction of the ocelot's overall distribution. Reduced

genetic variability in Texas ocelots suggests that this small population has been isolated from conspecifics for many generations. The widespread conversion of thornscrub habitat to agriculture and other intensive land uses has not only reduced the total population, but has reduced the potential for habitat fragments to be reached by dispersing ocelots, and has made the natural recolonization of vacant range unlikely. Such isolation is exacerbated by the proliferation of highways throughout the region, and the subsequent habitat effects and mortality that directly impact both resident and dispersing ocelots.

In the absence of population expansion and the restoration of demographic linkages with other populations, the ocelot in Texas faces a high risk of extinction in less than 40 years as the result of the combined effects of reduced genetic variability and environmental stochasticity (Miller 2005). Successful recovery will be the product of population management that improves genetic fitness and population size, and longer term efforts that protect and restore habitat, enhance landscape linkages among populations, promote range expansion, and reduce threats from roads and other sources of development-related mortality (Haines et al. 2005a).

ASMU: Less is known about this population. Lopez Gonzalez (2003) estimated a population of 2,025 ± 675 in the State of Sonora. However, with such a wide confidence interval based on relatively short-term efforts, a more refined estimate is needed. Further, there have been no field studies conducted to examine population density, demographics, habitat use, food habits, and spatial ecology.

International border issues such as fencing, lighting, U.S. Border Patrol and illegal immigrant activities including vehicle and pedestrian traffic, and habitat alteration to facilitate law enforcement and reduce illegal immigration into the U.S. are increasing threats to the ocelot in this area. These challenges can be addressed, in part, through interagency cooperation and research. Recovery planning for the ASMU should focus on basic research that details habitat suitability, distribution, and threats. More than two decades of research investment in the Texas/Tamaulipas population have been necessary to understand the spatial and demographic challenges of recovery planning in this area. Certainly, many of the issues facing the current ocelot population in Texas will pertain to ocelots that may be in Arizona, or in populations that are identified in Sonora. Nonetheless, dramatic climatic and landscape differences will dictate original research and conservation planning for the ASMU.

As previously stated, the ocelot is listed as endangered throughout its range, which includes 21 countries in addition to the United States. The entire species is the listed entity. In this recovery plan, we have identified two recovery management units for the Texas/Tamaulipas and Arizona/Sonora subspecies, *L. p. albescens* and *L. p. sonoriensis*, respectively. At this time, these management units cover the range of these two ocelot subspecies and only represent "potential" distinct population segments (DPSs) or subspecies units. These management units cannot be considered for delisting separately from the listed entity (i.e., the entire species) until it meets both the recovery criteria for each unit and has completed a formal reclassificaiton evaluation and designation, which would involve a proposed rulemaking, public review and comment, and a final rulemaking (USFWS and NMFS 1996, 61 FR 4722). We used a combination of geographic distribution and separation, genetic differences, geopolitical boundaries, and distinct habitat conditions to assess the designation of these TTMU and ASMU "potential" DPSs or subspecies units.

2.1.3 Recovery Objectives

Recovery objectives collectively describe the specific conditions under which the goals for recovery of the ocelot will be met. These objectives apply to the recovery of the ocelot throughout its range and the five listing factors:

1) Assess, protect, and restore sufficient habitat to support viable populations of the ocelot in the borderlands of the United States and Mexico (Listing Factor A).
2) Reduce the effects of human population growth and development on ocelot survival and mortality (Listing Factors A,E).
3) Maintain or improve genetic fitness, demographic conditions, and health of the ocelot (Listing Factors C,E).
4) Assure the long-term viability of ocelot conservation through partnerships, the development and application of incentives for landowners, application of existing regulations, and public education and outreach (Listing Factors A,D,E).
5) Practice adaptive management in which recovery is monitored and recovery tasks are revised by the USFWS in coordination with the Recovery Team as new information becomes available.
6) Support international efforts to ascertain the status of and conserve the ocelot south of Tamaulipas and in Sonora (Listing Factors A,B,C,D,E).

Please see "Reasons for Listing/Threats" for a description of the five Listing Factors.

2.1.4 Recovery Criteria

Recovery criteria are the objective, measurable criteria that if met, provide a basis for determining whether a species can be considered for reclassification (downlisting to threatened status or removing it from the list of threatened and endangered species [delisted]). Because the same five statutory factors must be considered in delisting as in listing, 16 U.S.C. § 1533 (a), (b),(c), the USFWS, in designing objective, measurable criteria, must address each of the five statutory delisting factors and measure whether threats to the [species] have been ameliorated (see Fund for Animals v. Babbitt, 903 F. Supp. 96 (D.D.C1995). The criteria below were established for the ocelot throughout its range, as listed by the ESA to the maximum extent practicable, with specific objectives that can be met for the borderland management units. If these are met, the borderland populations could be considered for reclassification as Distinct Population Segments or as subspecies, and be considered for downlisting or delisting as such. We submit that the approach described above meets our statutory requirements to the maximum extent practicable. As our knowledge of the ocelot range-wide increases and as the recovery actions described in this plan are implemented, the plan may be revised and refined.

Downlisting Criteria

The ocelot should be considered for downlisting to threatened status when:

1. Populations south of Tamaulipas and Sonora have been reevaluated by the IUCN Cat Specialist Group (due by 2012) and continue to qualify for "Least Concern" under the International Union of Concerned Scientists (IUCN) Red List criteria (World Conservation Union, 2008, http://www.iucnredlist.org) for five years after this reevaluation. Threats from habitat loss, habitat fragmentation, and poaching have been reduced such that the ocelot is no longer in danger of extinction. The IUCN currently lists the ocelot (except supbspecies *L. p. albescens*) as "Least Concern" with a decreasing global population trend (Cat Specialist Group 2008). The Texas/Tamaulipas ocelot was assessed as a separate subspecies by the IUCN Cat Specialist Group in 1996 and meets "Endangered" criteria B (occupied area <5000 km^2, fragmented populations, declining area of occupancy), D (<250 mature individuals), and E (high probability of extinction within 100 years) (Cat Specialist Group 1996).

Rational for Downlisting Criterion 1: We acknowledge that this criterion is broad and general, but it was developed to the maximum extent practicable based on our limited knowledge of the species throughout its range south of Tamaulipas and Sonora. As we learn more about the species in this part of its range, this criterion may be modified in the future.

2. The TTMU population is estimated through reliable scientific monitoring to be above 200 in Texas and 1,000 in Tamaulipas for at least 5 years. The 200 ocelots in Texas should be distributed as either (1) a single core population of at least 150 ocelots with interchange between it and ocelots in Tamaulipas that is sufficient to maintain genetic variability; or (2) at least 2 core populations of 75 ocelots each, with interchange between the 2 core populations and between the core populations and ocelots in Tamaulipas that is sufficient to maintain genetic variability. Interchange may be facilitated by moving ocelots between populations to simulate natural dispersal and recruitment. Core populations may include the current populations at LANWR and Kenedy-Willacy, but may also include a reintroduced population established within currently unoccupied historical range. Habitat protection must be in place to support core ocelot populations for the foreseeable future, and potential corridors and mechanisms must be identified to restore habitat connectivity between core populations.

Rationale for Downlisting Criterion 2:

> <u>Minimum sizes of core population in Texas of 75 ocelots</u>. The results of the ocelot PVA (Appendix IV) indicate that sizes of current populations in Texas (30 and 40 ocelots for LANWR and Kenedy-Willacy, respectively) are not sufficient to avoid extinction of the species in Texas within the next 100 years. Increasing the initial population size in the PVA to 70 ocelots reduces the extinction risk of a population compared to initial population sizes of 50 or 60 ocelots under a variety of conditions (Appendix IV, Table 4, Figure 4). Population sizes of 70 ocelots in Texas are also achievable with the implementation of feasible habitat enhancement tasks identified in the plan.
>
> <u>Minimum population size in Tamaulipas of 1,000 ocelots</u>. The PVA (Appendix IV) suggests that the number of translocated ocelots needed to maintain the Texas populations would demographically impact the source population in Tamaulipas. A population of 1,000 ocelots in Tamaulipas would reduce the proportion of the population

that would be translocated and result in a much smaller demographic impact to the Tamaulipan population. A population of 1,000 is also realistic and could represent the current population of ocelot in the entire State of Tamaulipas.

3. The ASMU population is estimated through reliable scientific monitoring to be above 1,000 animals for 5 years. Habitat linkages to support an ASMU metapopulation have been identified. Threats to this population have been identified and are determined to be below the threshold of endangerment of extinction within the foreseeable future. Methods to address significant threats have been identified. Currently this population meets the "Data Deficient" category as determined by the IUCN (World Conservation Union 2006, http://www.iucnredlist.org).

Rationale for Downlisting Criterion 3:

Minimum population size of 1,000 ocelots in the ASMU population. Based on the results of the PVA for the ocelot in south Texas and northern Tamaulipas, we determined that 1,000 animals are needed for the persistence of the ASMU into the foreseeable future. Lopez Gonzalez et al. (2003) estimated a Sonoran population of 2,025 $\pm$ 675 ocelots. We surmise that more research is needed to refine this estimate, but a minimum population size of 1,000 animals is appropriate and within the confidence limits of the 2003 estimate. As additional monitoring and population data are acquired for the ASMU, this recovery criterion may need to be modified in the future.

Delisting Criteria

The ocelot should be considered for delisting when:

1. Populations south of Tamaulipas and Sonora have been reevaluated by the IUCN Cat Specialist Group (due by 2012) and continue to qualify for "Least Concern" under the IUCN Red List criteria (World Conservation Union, 2006, http://www.iucnredlist.org) for 10 years after this reevaluation and populations are stable or increasing. Threats from habitat loss, habitat fragmentation, and poaching are reduced such that the ocelot can maintain healthy, viable populations for the foreseeable future.

Rational for Delisting Criterion 1: This is similar to Downlisting Criterion 1, except it was extended over a longer time frame to ensure populations are sufficiently stable.

2. The TTMU population is estimated through reliable scientific monitoring to be above 200 in Texas and 1,000 in Tamaulipas for at least 10 years. The 200 ocelots in Texas should be distributed as either (1) a single core population of at least 150 ocelots with interchange between it and ocelots in Tamaulipas that is sufficient to maintain genetic variability; or (2) at least 2 core populations of 75 ocelots each, with interchange between the 2 core populations and between the core populations and ocelots in Tamaulipas that is sufficient to maintain genetic variability. Interchange among populations must occur through natural dispersal rather than by moving ocelots between population; or (3) if natural interchange between Texas and Tamaulipas is impossible, cross-border interchange may be facilitated by moving ocelots to simulate natural dispersal and recruitment *and* an additional population of at least 75 ocelots should be

established within currently unoccupied historical range in Texas. This additional population should be established in a location that would expand the geographical range of the species in Texas to provide sufficient insurance against loss of the entire Texas population from catastrophic weather events or infectious disease. Habitat protection must be in place to support and connect all core ocelot populations within Texas and within Tamaulipas for the foreseeable future.

Rationale for Delisting Criterion 2:

This delisting criterion differs from element two of the downlisting criterion as follows:

> <u>The criteria must be met for 10 years</u>. The increase in time is appropriate to ensure that the populations and their management are sufficiently stable to project that the population is recovered.
>
> <u>Connectivity among populations is through natural dispersal rather than by translocation.</u> Adequate natural corridors for dispersal should be more reliable because they do not rely on long-term commitments by management agencies to translocate animals. In addition, natural connectivity avoids or minimizes the risk to individual animals by capture and handling and avoids the disruption of local populations by removal or supplementation.
>
> <u>Allows for the establishment of an additional Texas population as an alternative to natural colonization from Tamaulipas.</u> This allows for delisting even if natural connectivity cannot be maintained between Texas and Tamaulipas, by substantially increasing the security of the species in Texas.

3. The ASMU population is estimated through reliable scientific monitoring to be above 1,000 animals for 10 years. Significant threats to this population have been identified and addressed. Habitat linkages to facilitate an ASMU metapopulation have been identified and are conserved for the foreseeable future.

Rational for Delisting Criterion 3: This is similar to Downlisting Criterion 3, except it was extended over a longer time frame to ensure populations are sufficiently stable.

Threats Tracking Table

SUMMARY OF OCELOT LISTING FACTORS AND THREATS AND THE RECOVERY ACTIONS TO CONTROL THOSE THREATS			
<u>Listing Factor</u>	<u>Threats</u>	<u>Recovery Criteria</u>	<u>Recovery Actions</u>
ALL	**All threat factors:**	1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
(A, B, C, D, E	**A = habitat modification or loss**	3	1.4 Identify threats to ASMU populations
Collectively)	**B = overutilization**	3	1.5 Reduce, alleviate threats to ASMU
	C = disease, predation	1,2,3	2.1.4.1 Support interagency planning
	D = inadequacy of regulations	2,3	4.1.1 Develop recovery working groups
	E = other natural or manmade factors	1,2,3	4.1.2 Continue recovery through subgroups
		2,3	4.1.6 Develop partnerships with Mexico
		2	5.1 Develop monitoring plan for core populations
		2	5.2 Develop agreements for non-federal land surveys
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare report of ocelot monitoring
		1,2,3	6.1 Track skin locations
		1,2,3	6.2.1 Provide support for workshops
		1	6.2.2 Support Meso-american corridor
Factor A	**Population and Habitat Loss**	2	1.1.1 Map habitat in Texas
		2	1.1.2 Map habitat in Tamaulipas
		2	1.1.3 Document status in Texas habitat
		2	1.1.4 Document status in Tamaulipas habitat
		2	1.1.5 Estimate areas needed in Texas
		2	1.1.6 Identify conservation lands in TTMU range
		1,2,3	1.2.3.1 Protect habitat around core populations
		1,2,3	1.2.3.2 Connect known Texas populations
		1,2,3	1.2.3.3 Protect habitat recently occupied by ocelots
		1,2,3	1.2.3.4 Create a bi-national corridor connecting Texas and Tamaulipas ocelot populations
		1,2,3	1.2.3.5 Protect habitat in the historic range of the ocelot in Arizona, Sonora, Tamaulipas, and Texas
		3	1.3.1.1 Map habitat in Sonora and AZ
		3	1.3.1.2 Expand surveys in ASMU habitat
		3	1.3.1.3 Establish 3+ monitoring areas in Sonora and Arizona
		3	1.3.1.4 Identify lands in ASMU range
		2	3.1.1 Monitor genetic diversity, evaluate genetic augmentation in Texas
		2	3.1.2 Monitor genetic diversity, evaluate genetic augmentation in Tamaulipas
		3	3.1.3 Characterize genetic status in Sonora
		2	3.1.4 Develop genetic augmentation for core populations
		2,3	3.1.5 Evaluate artificial reproduction, gene bank
		2	3.1.6 Evaluate genetic breeding program

		2	3.2.1 Conduct experimental translocations
		2	3.2.2 Augment populations through translocation
		2	3.2.3 Evaluate use of confiscated ocelots
		2	3.3 Identify area for new population in TX
		2	3.4 Establish new population in TX
Factor A	**Habitat Modification (Management)**	1,2,3	1.2.1 Develop, distribute, implement habitat guidelines
		1,2,3	1.2.2 Foster partnerships with landowners
		3	1.4 Identify threats to ASMU populations
		3	1.5 Identify ASMU threats reduction, alleviation
		1,2,3	2.1.4.1 Support interagency planning
		1,2,3	2.3 Minimize impacts from other development and human activities
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		1,2,3	4.1.5 Support Mexican habitat surveys
		2,3	4.1.6 Partner with Mexican agencies, landowners
		2,3	4.1.7 Partner with Homeland Security, Border Patrol
		2,3	4.2.2 Assure compliance of oil, gas, seismic operations
		2,3	4.3.1 Maintain education/outreach working group
		2	4.3.2.1 Develop education materials for TX and AZ
		2,3	4.3.2.2 Develop education materials for Tamaulipas, Sonora
		2,3	4.3.3 Monitor, evaluate outreach efforts
		2	5.1 Develop monitoring protocol for core populations
		2	5.2 Develop agreements to survey on non-federal land
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	6.1 Track skin locations internationally
		1,2,3	6.2.1 Support workshops every 3-5 years
		1	6.2.2 Support implementation of Meso-american corridor
Factor A	**Habitat Degradation**	2,3	1.1.10 Identify, prioritize lands for habitat restoration
		2	1.2.4.1 Develop methods to restore Tamaulipan thornscrub
		2	1.2.4.2 Identify, map soils for thornscrub restoration
		2	1.2.4.3 Restore thornscrub around core Texas populations
		2	1.2.4.4 Prioritize, implement thornscrub restoration
		2	1.2.4.5 Implement thornscrub restoration monitoring
Factor A	**Loss of Habitat Connectivity**	2	1.1.7 Map connections between TTMU populations
		1,2,3	1.1.8 Study dispersal of ocelots
		1,2,3	1.1.9 Model movement and dispersal
		1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
		1,2,3	1.3.2.2 Determine movements and dispersal in Arizona and Sonora

		1,2,3	1.3.2.3 Identify conduits and barriers in Arizona and Sonora
		1,2,3	1.3.2.4 Identify food and prey habits in Sonora
		2,3	2.2.1 Identify border crossings
		2,3	2.2.2 Reduce impacts of border structures
		2,3	2.2.3 Maintain, enhance border thornscrub and other appropriate habitats
Factor A	**Road Fragmentation and Mortality**	2	1.1.11 Identify, maintain habitat linkages and crossing structures in south Texas and Arizona
		2	2.1.1 Quantify road and bridge effects, road density threshold
		2	2.1.2 Identify locations for road-crossing structures
		2	2.1.3 Design crossing structures, features
		2,3	2.1.4.2 Minimize new road and bridge impacts
		2,3	2.1.4.3 Implement crossing structures and designs
		2	2.1.4.4 Construct crossing structures in heavy use zones
Factor B	**Overutilization**	3	1.3.1.3 Establish monitoring areas in Arizona and Sonora
		1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
		3	1.4 Identify threats to ASMU populations
		3	1.5 Identify ASMU threats reduction, alleviation
		1,2,3	2.1.4.1 Support interagency planning
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		2,3	4.1.6 Partner with Mexican agencies, landowners
		2,3	4.3.1 Maintain education/outreach working group
		2	4.3.2.1 Develop education materials for TX and Arizona
		2,3	4.3.2.2 Develop education materials for Tamaulipas, Sonora
		2,3	4.3.3 Monitor, evaluate outreach efforts
		1,2,3	4.3.4 Educate hunters to refrain from killing ocelots
		2	5.1 Develop monitoring protocol for core populations
		2	5.2 Develop agreements to survey on non-federal land
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	6.1 Track skin locations internationally
		1,2,3	6.2.1 Support workshops every 3-5 years
		1	6.2.2 Support implementation of Meso-american corridor
Factor C	**Disease, Toxins, Predation**	1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
		1,2,3	1.3.2.4 Identify food and prey habits in Sonora
		3	1.4 Identify threats to ASMU populations
		3	1.5 Reduce, alleviate threats to ASMU
		1,2,3	2.1.4.1 Support interagency planning

		2,3	3.5.1 Establish physiological, identification protocols
		2,3	3.5.2 Conduct serology and pathology surveys
		2,3	3.5.3 Create tissue bank
		2,3	3.5.4 Establish protocols for injury, diseases, parasites
		1,2,3	3.5.5 Establish medical and genetic database
		1,2,3	3.5.6 Investigate disease prevention
		2,3	3.6.1 Research contamination
		1,2,3	3.7.1 Research niche overlap with competitors, predators
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2,3	4.1.6 Partner with Mexican agencies, landowners
		2	5.1 Develop monitoring protocol
		2	5.2 Develop agreements to survey on non-federal land
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	5.5 Develop data sharing and repository
		1,2,3	6.1 Track skin locations internationally
		1,2,3	6.2.1 Support workshops every 3-5 years
		1	6.2.2 Support implementation of Meso-american corridor
Factor D	**Inadequacy of Regulation**	3	1.3.1.3 Establish 3+ monitoring areas in Sonora and Arizona
		1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
		3	1.4 Identify threats to ASMU populations
		3	1.5 Identify ASMU threats reduction, alleviation
		1,2,3	2.1.4.1 Support interagency planning
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		2,3	4.1.6 Partner with Mexican agencies, landowners
		1,2,3	4.2.1 Encourage regulations in Mexico
		2,3	4.2.2 Assure compliance of oil, gas, seismic operations
		2,3	4.3.1.2 Develop education materials for Tamaulipas, Sonora
		2,3	4.3.3 Monitor, evaluate outreach efforts
		2	5.1 Develop monitoring protocol
		2	5.2 Develop agreements to survey on non-federal land
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	6.1 Track skin locations internationally
		1,2,3	6.2.1 Support workshops every 3-5 years
		1	6.2.2 Support implementation of Meso-american corridor
Factor E	**Roads**	2	1.1.11 Identify, maintain habitat linkages and necessary crossing structures in south Texas and Arizona

		1,2,3	1.1.8 Study dispersal
		1,2,3	1.1.9 Model movement and dispersal
		1,2,3	1.3.2.1 Determine habitat selection in Sonora and Arizona
		1,2,3	1.3.2.2 Determine movements and dispersal in Sonora and Arizona
		1,2,3	1.3.2.3 Identify conduits and barriers in Sonora and Arizona
		2	2.1.1 Quantify road effects, road density threshold
		2	2.1.2 Identify locations for road-crossing structures
		2	2.1.3 Design crossing structures, features
		2,3	2.1.4.2 Minimize new road impacts
		2,3	2.1.4.3 Implement crossing structures and designs
		2	2.1.4.4 Construct crossing structures in heavy use zones
Factor E	**Border issues**	1,2,3	1.1.8 Study dispersal
		1,2,3	1.1.9 Model movement and dispersal
		2,3	2.2.1 Identify border crossings
		2,3	2.2.2 Reduce impacts of border structures
		2,3	2.2.3 Maintain, enhance border thornscrub habitats
		2,3	4.1.6 Partner with Mexican agencies, landowners
		2,3	4.1.7 Partner with Homeland Security, Border Patrol
		2,3	4.3.1 Maintain education/outreach working group
		2	4.3.2.1 Develop education materials for TX
		2,3	4.3.2.2 Develop education materials for Tamaulipas, Sonora
		2,3	4.3.3 Monitor, evaluate outreach efforts
Factor E	**Genetics**	2	3.1.1 Monitor genetic diversity, evaluate genetic augmentation in Texas
		2	3.1.2 Monitor genetic diversity, evaluate genetic augmentation in Tamaulipas
		3	3.1.3 Characterize genetic status in Sonora
		2	3.1.4 Develop genetic augmentation
		2,3	3.1.5 Evaluate artificial reproduction, gene bank
		2	3.1.6 Evaluate genetic breeding program
		2	3.2.1 Conduct experimental translocations
		2	3.2.2 Augment populations through translocation
		2	3.2.3 Evaluate use of confiscated ocelots
		2	3.3 Identify area for new population in TX
		2	3.4 Establish new population in TX
		1,2,3	3.5.5 Establish medical and genetic database
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		2,3	4.1.6 Partner with Mexican agencies, landowners
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results

		1,2,3	5.5 Develop data sharing and repository
		1,2,3	6.3 Coordinate genetic zoo data
Factor E	**Pesticides, Herbicides**	2,3	3.5.1 Establish physiological, identification protocols
		2	3.5.2 Conduct serology and pathology surveys
		2,3	3.5.3 Create tissue bank
		2,3	3.5.4 Establish protocols for injury, diseases, parasites
		1,2,3	3.5.5 Establish medical and genetic database
		2,3	3.6.1 Research contamination
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		2,3	4.1.6 Partner with Mexican agencies, landowners
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	5.5 Develop data sharing and repository
Factor E	**Competition**	1,2,3	1.3.2.4 Identify food and prey habits
		1,2,3	3.7.1 Research niche overlap with competitors
Factor E	**Information Needs**	2	1.1.5 Estimate areas needed in Texas
		2	1.1.6 Identify conservation lands in TTMU range
		1,2,3	1.1.8 Study dispersal
		1,2,3	1.1.9 Model movement and dispersal
		1,2,3	1.2.2 Foster partnerships
		3	1.3.1.2 Expand surveys in ASMU habitat
		3	1.3.1.3 Establish 3+ monitoring areas in Sonora and Arizona
		3	1.4 Identify threats to ASMU populations
		3	1.5 Identify ASMU threats reduction
		2,3	4.1.1 Develop recovery working groups
		1,2,3	4.1.2 Continue recovery through subgroups
		2	4.1.3 Develop projects with landowners
		2	4.1.4 Develop incentive programs for landowners
		2,3	4.1.6 Partner with Mexican agencies, landowners
		2,3	4.1.7 Partner with Homeland Security, Border Patrol
		2,3	4.3.1 Maintain education/outreach working group
		2	4.3.2.1 Develop education materials for TX and Arizona
		2,3	4.3.2.2 Develop education materials for Tamaulipas, Sonora
		2,3	4.3.3 Monitor, evaluate outreach efforts
		2	5.1 Develop monitoring protocol
		2	5.2 Develop agreements to survey on non-federal land
		1,2,3	5.3 Conduct monitoring of recovery
		1,2,3	5.4 Prepare annual report of monitoring results
		1,2,3	5.5 Develop data sharing and repository

		1,2,3	6.1 Track skin locations internationally
		1,2,3	6.2.1 Support workshops every 3-5 years
		1	6.2.2 Support implementation of Meso-american corridor
Factor E	**Natural Factors - Drought**	1	1.2.5 Provide available drinking water

Outline of Recovery Actions

Underlined recovery actions represent the most stepped-down levels for the recovery program narrative. These items are discrete, specific actions and are the actions listed in the Implementation Schedule found at the end of this document.

1. **Assess, protect, and enhance ocelot populations and habitat in the borderlands of the U.S. and Mexico**.
   - 1.1. Develop a comprehensive habitat model for conservation of ocelots in the TTMU that address core population needs and habitat connectivity
     - 1.1.1. Map existing brushlands suitable for supporting ocelots in Texas
     - 1.1.2. Map existing brushlands suitable for supporting ocelots in Tamaulipas
     - 1.1.3. Document the status of ocelots in known and potential habitat in Texas
     - 1.1.4. Document the status of ocelots in known and potential habitat in Tamaulipas
     - 1.1.5. Estimate the area necessary to support 200 ocelots in Texas and 1,000 ocelots in Tamaulipas
     - 1.1.6. Identify existing and proposed conservation lands in current and potential ocelot range in Texas and Tamaulipas
     - 1.1.7. Identify, field verify, and map the most practical connections between areas of TTMU populations
     - 1.1.8. Study ocelot dispersal behavior
     - 1.1.9. Develop computer simulations to identify and predict the conditions associated with dispersal and movement of ocelots
     - 1.1.10. Identify and prioritize lands for habitat restoration
     - 1.1.11. Collaborate with landowners and experts to develop feasible landscape design to manage habitat and specify the location and types of crossing structures at roads necessary to maintain linkages in south Texas
   - 1.2. Develop and implement strategies to preserve and expand habitat and enhance habitat connectivity in the TTMU
     - 1.2.1. Develop, distribute, and implement guidelines for managing and enhancing existing ocelot habitat
     - 1.2.2. Develop and implement strategies and incentives to foster partnerships and enlist landowner cooperation
     - 1.2.3. Where feasible, prioritize and acquire necessary conservation easements/lands
       - 1.2.3.1. Protect habitat occupied by and surrounding known ocelot populations.
       - 1.2.3.2. Protect a corridor of habitat to connect known populations in Texas.
       - 1.2.3.3. Protect habitat in areas recently occupied by ocelots.
       - 1.2.3.4. Protect a bi-national corridor of habitat to connect the Cameron County ocelot population to the northernmost known ocelot population in Tamaulipas.
       - 1.2.3.5. Protect habitat in other portions of the historic range in Arizona, Texas, Sonora, and Tamaulipas.
     - 1.2.4. Restore thornscrub habitat
       - 1.2.4.1. Develop methodologies for thornscrub restoration
       - 1.2.4.2. Identify and map appropriate soils for thornscrub restoration
       - 1.2.4.3. Restore thornscrub habitat around core ocelot populations in Texas.
       - 1.2.4.4. Implement thornscrub restoration on a priority basis to benefit ocelots

1.2.4.5. Develop and implement a monitoring program for restored thornscrub
1.2.5. Assure available drinking water during periods of drought
1.3. Determine the status, trends, ecology, and threats to ocelots in the ASMU.
1.3.1. Refine current distribution map of the regional population.
1.3.1.1. Map existing habitat suitable for supporting ocelots in Sonora and Arizona
1.3.1.2. Continue and expand surveys to document the presence of ocelots in known and potential habitat
1.3.1.3. Establish a minimum of three long-term monitoring areas in Sonora and Arizona
1.3.1.4. Identify existing and proposed conservation lands in current and potential ocelot range in Sonora and Arizona
1.3.2. Determine spatial requirements of ocelot population in Sonora and if possible, Arizona
1.3.2.1. Determine habitat selection in Sonora and Arizona
1.3.2.2. Determine daily and seasonal movements, including patterns of subadult dispersal in Sonora and Arizona
1.3.2.3. Identify conduits and barriers to movements in Sonora and Arizona
1.3.2.4. Identify food habits, prey preferences, prey abundance and distribution in Sonora and Arizona
1.4. Identify significant threats to ASMU populations
1.5. Identify mechanisms to reduce or alleviate significant threats to ASMU populations

2. Reduce the effects of human population growth and development on the ocelot

2.1. Reduce road impacts to ocelots
2.1.1. Avoid, reduce, and minimize impacts of roads and bridges to the ocelot. Quantify the effects of roads and bridges on habitat suitability and determine road density threshold for ocelots
2.1.2. Identify optimal locations for crossing structures
2.1.3. Identify design specifications for crossing structures and other features to reduce mortality
2.1.4. Engage Federal and State Departments of Transportation in ocelot conservation
2.1.4.1. Support participation in interagency planning to conserve ocelots
2.1.4.2. Minimize the impacts of new roads and bridges in ocelot habitat and corridors (section 7 consultations)
2.1.4.3. Where new roads or bridges are unavoidable, implement crossing structures and other appropriate designs to minimize road mortality and habitat loss
2.1.4.4. Construct new crossing structures or other design features on existing roads to reduce mortality in areas of heavy ocelot use
2.2. Avoid, reduce, and minimize U.S.-Mexican border infrastructure, maintenance, and development impacts on ocelot habitat and behavior
2.2.1. Identify strategic locations for ocelot border crossings
2.2.2. Avoid and reduce impacts of border-associated structures, including ensuring border fences in ocelot habitat allow for the passage of ocelots
2.2.3. Maintain and enhance protective thornscrub and other appropriate habitats near the border

- 2.3. Avoid, reduce, or minimize impacts from other development projects and human activities, including residential and commercial construction, wind farms, and other developments and activities in ocelot habitat or corridors (section 7 consultations).

3. **Maintain or improve genetic fitness, demographic conditions, and health of the ocelot in borderland populations**
   - 3.1. Maintain or increase genetic diversity within core populations
     - 3.1.1. Monitor genetic health and diversity in Texas ocelot populations; evaluate genetic augmentation
     - 3.1.2. Monitor genetic health and diversity in Tamaulipas ocelot populations; evaluate genetic augmentation
     - 3.1.3. Characterize the genetic status and variability of the ocelot in Sonora
     - 3.1.4. Design a genetic and population augmentation program and protocols for core populations as necessary
     - 3.1.5. Evaluate the need and feasibility of artificial reproductive techniques to manage genetic diversity; if appropriate, implement techniques for and development of a genetic gamete tissue bank program
     - 3.1.6. Evaluate the need and efficacy of establishing a captive breeding program
   - 3.2. Increase the number of ocelots in core populations as necessary
     - 3.2.1. Conduct experimental translocations
     - 3.2.2. Augment existing populations as necessary through translocation
     - 3.2.3. Evaluate the feasibility of using confiscated ocelots to augment populations
   - 3.3. Identify an area for establishing a new ocelot population within historic range in Texas
   - 3.4. If an area suitable for a new ocelot population is identified, establish a new population within historic range in Texas
   - 3.5. Protect ocelots from life threatening diseases, parasites, and injuries
     - 3.5.1. Establish protocols for physiological assessment and individual identification
     - 3.5.2. Conduct serology and pathology surveys to determine genetic profile, overall condition, and the presence and effect of diseases and parasites
     - 3.5.3. Create a tissue bank for ocelot samples
     - 3.5.4. Establish protocols for treatment of injury, diseases, and parasites as appropriate
     - 3.5.5. Establish a database of medical and genetic ocelot data
     - 3.5.6. Investigate measures to prevent disease
   - 3.6. Identify and reduce the impacts of environmental contaminants on the ocelot
     - 3.6.1. Conduct research that identifies pathways of contamination in ocelots and their prey and provides solutions to existing toxicity problems
   - 3.7. Investigate competitive interactions among bobcat, coyote, and ocelot
     - 3.7.1. Conduct field studies designed to explicate the degree of niche overlap between the ocelot and its potential competitors

4. **Assure the long-term success of ocelot conservation through partnerships, landowner incentives, community involvement, application of regulations, and public education and outreach**
   - 4.1. Develop partnerships with other agencies, organizations, and citizens
     - 4.1.1. Develop regional recovery working groups that practice broad-based community planning for ocelot conservation
     - 4.1.2. Continue momentum for recovery through the implementation and technical subgroups of the Recovery Team

- 4.1.3. Restore and protect habitat through cooperative conservation projects such as Safe Harbor Agreements, Habitat Conservation Plans, acquiring key property through easements or fee title with willing landowners on non-Federal lands in the U.S.
- 4.1.4. Develop incentive programs for landowners that have existing brush to implement recovery on non-Federal lands in the U.S.
- 4.1.5. Support work by biologists in Mexico to survey existing and potential habitat
- 4.1.6. Develop partnerships with Mexican agencies and landowners to implement recovery actions
- 4.1.7. Encourage participation by the Department of Homeland Security and the U.S. Border Patrol with agencies responsible for ocelot conservation

4.2. Protect the ocelot by using or developing regulations where necessary

- 4.2.1. Encourage development and enforcement of regulations in Mexico to protect ocelots
- 4.2.2. Assure compliance with existing regulations for oil and gas development and seismic exploration that could negatively affect the ocelot

4.3. Expand education and outreach to promote ocelot conservation

- 4.3.1. Maintain an education/outreach working group under the Ocelot Recovery Team Implementation Subgroup to coordinate efforts for the ocelot
- 4.3.2. Develop a regional outreach plan for the TTMU and ASMU
  - 4.3.2.1. Develop education materials and plans for Texas and Arizona
  - 4.3.2.2. Develop education materials and plans for Tamaulipas and Sonora
- 4.3.3. Monitor and assess the effectiveness of outreach efforts
- 4.3.4. Educate hunters, landowners, and predator control personnel to recognize ocelots and refrain from killing them

5. Practice adaptive management in which recovery is monitored and recovery tasks are revised by USFWS in coordination with Recovery Team subgroups as new information becomes available

- 5.1. Develop a monitoring schedule and protocol for core populations
- 5.2. Develop agreements with willing landowners to survey for and monitor populations and habitats on non-Federal lands
- 5.3. Conduct monitoring
- 5.4. Prepare annual reports of ocelot monitoring results
- 5.5. Develop cooperation among agencies and organizations for data sharing and data repository

6. Support efforts to ascertain the status and conserve ocelot populations south of Tamaulipas and Sonora

6.1. Track locations of skins to determine source of illegal harvest

6.2. Promote data collection and sharing among countries with ocelots

- 6.2.1. Provide support for a routine workshop every three to five years to gather ocelot information
- 6.2.2. Support efforts of international conservation groups to implement the Meso-American corridor (formerly the Paseo Pantera Corridor)

6.3. Coordinate recommendations and available genetic data from international zoos

Narrative of Recovery Actions

Underlined recovery actions represent the most stepped-down levels of the recovery program narrative. These items are discrete, specific actions and are the actions listed in the Implementation Schedule found at the end of this document.

1. Assess, protect, and enhance ocelot populations and habitat in the borderlands of the U.S. and Mexico.

1.1. Develop a comprehensive habitat model for conservation of ocelots in the TTMU that addresses core population needs and habitat connectivity.

1.1.1. Map existing brushlands suitable for supporting ocelots in Texas. GIS maps of all remaining brushlands in Texas should be developed to determine where suitable habitat remains, where populations may be found or reestablished, and where it may be feasible to establish habitat connectivity through restoration.

1.1.2. Map existing brushlands suitable for supporting ocelots in Tamaulipas. Identification of existing habitat in Tamaulipas is vital to monitoring and protecting this population. This population may provide genetic and demographic enhancement essential to ocelot populations in the U.S. Ideally, landscape linkages will facilitate interchange between ocelot populations in these countries.

1.1.3. Document the status of ocelots in known and potential habitat in Texas. A focus on building relationships and trust with landowners is necessary to obtain information about ocelots on private lands. A combination of efforts using remote imaging technology, ocelot sign, camera traps, hairs snares, existing reports, and accessing unsurveyed lands will be needed.

1.1.4. Document the status of ocelots in known and potential habitat in Tamaulipas. The northernmost population in Tamaulipas is estimated at approximately 200 animals, but less is known further south. A combination of efforts using remote imaging technology, ocelot sign, camera traps, anecdotal information, and accessing unsurveyed lands will be needed.

1.1.5. Estimate the area necessary to support 200 ocelots in Texas and 1,000 ocelots in Tamaulipas. This action will require analysis of digital land cover data, field verification, and integration of the most current knowledge of ocelot habitat requirements.

1.1.6. Identify existing and proposed conservation lands in current and potential ocelot range in Texas and Tamaulipas. A graphic representation of all occupied and suitable areas in Texas and Tamaulipas is fundamental to understanding population dynamics, potential locations for corridors, and long-term population sustainability. It will be necessary to identify and prioritize those lands most critical to target for conservation status.

1.1.7. Identify, field verify, and map the most practical connections between areas of existing and potential ocelot populations. Identification of linkages will be a critical component of a comprehensive habitat conservation model. Priority should be given to areas with minimal need for habitat restoration and a maximum potential for long-term protection.

1.1.8. Study ocelot dispersal behavior. A better understanding of ocelot dispersal behavior and associated demography should be obtained using current satellite monitoring technology.

1.1.9. Develop computer simulations to identify and predict the conditions associated with dispersal and movement of ocelots. Software such as that available for use with ArcMAP GIS (e.g., cost Distance Grid extension; ESRI, Redland, CA) is useful for modeling the virtual resistance of a landscape to the movements of wide-ranging carnivores (Larkin et al. 2004). Such modeling can assist with the identification of dispersal barriers, filters, and conduits, and can be an aid in designing blueprints for habitat restoration and habitat protection. Beier et al. (2006) described other GIS approaches to linkage design.

1.1.10. Identify and prioritize lands for habitat restoration. Ultimately, adding habitat to the range of the ocelot will depend on the cooperation and interest of the landowner in restoration, or the availability of the land in question and the resources to acquire it or otherwise protect it. Where these challenges can be met, habitat with restoration potential should be prioritized according to its proximity to occupied range, its ability to serve as occupied range, and its utility as a landscape linkage between occupied areas. In addition, the difficulty of the restoration should be estimated and based on the condition of existing soils and vegetation (i.e., all things being equal, the area in need of less retrofitting should have a higher restoration priority than an area that requires more).

1.1.11. Collaborate with landowners and experts to develop feasible landscape designs to manage habitat and specify the location and types of crossing structures at roads necessary to maintain linkages in southern Texas. Linkages are needed between LANWR and Kenedy – Willacy populations; within coastal habitat for Texas – Mexico corridors; within Starr County for Texas – Mexico corridors; within Willacy County for east to west corridors; and in other areas as necessary.

1.2. Develop and implement strategies to preserve and expand habitat and enhance habitat connectivity in the TTMU.

1.2.1. Develop, distribute, and implement guidelines for managing and enhancing existing ocelot habitat. Guidelines, in the form of a detailed brochure or manual, should be developed that describe best management practices for ocelot habitat, tools and resources for assistance, and benefits and incentives for land managers.

Guidelines should be distributed to interested managers, landowners, and posted on appropriate web sites.

1.2.2. Develop and implement strategies and incentives to foster partnerships and enlist landowner cooperation. Successful recovery of the ocelot will require significant cooperation among organizations and participation of private landowners. Most of the important habitat for the species in both the U.S. and Mexico occurs on non-Federal lands or on public lands where wildlife may not be the primary target of management. Overcoming the perception that endangered species may be a liability on private lands is a significant challenge in parts of the species range, whereas, conflict with land use such as conversion to agriculture or development is more important in others. Strategies to conduct outreach to local communities and create incentives for their specific needs will need to be developed through the efforts of focused, long-term efforts. An outreach working group of the Recovery Team Implementation Subcommittee should be formed with this as a primary priority.

1.2.3. Where feasible, prioritize and acquire necessary conservation easements/lands. Land acquisition from willing sellers should be pursued as resources and necessity allow. The priorities for acquisition should be evaluated regularly and opportunities for funding through partnerships of interested organizations (e.g., non-traditional section 6 grants) aggressively pursued. Create a task force of the Implementation Team to provide the guidance and make initial contacts pertaining to this action.

1.2.3.1. Protect habitat occupied by and surrounding known ocelot populations. Habitat protection can include conservation easements or fee title acquisition from willing sellers. Protected habitat around LANWR in Cameron County and around currently occupied habitat in Willacy County must be expanded in order to meet recovery goals. In Willacy County, at least 4,000 acres of additional habitat around currently occupied habitat should be protected. Protection of habitat occupied by and surrounding known ocelot populations in Tamaulipas and Sonora should be promoted and supported through landowner agreements, national protection, or other programs in Mexico.

1.2.3.2. Protect a corridor of habitat to connect known populations in Texas. Accomplish connectivity by protecting at least 3,000 acres of habitat in a corridor at least 0.25 mile wide and approximately 19 miles long between the ocelot populations in Willacy and Cameron Counties. This protection can be accomplished through a combination of USFWS Partners agreements, conservation easements, or fee title acquisition from willing sellers.

1.2.3.3. Protect habitat in areas recently occupied by ocelots. Habitat protection can include conservation easements or fee title acquisition from willing sellers. Protected habitat in areas known to be recently occupied by ocelots, such as the area around the Salt Lakes Units of LRGVNWR, should be increased.

1.2.3.4. Protect a bi-national corridor of habitat to connect the Cameron County ocelot population to the northernmost known ocelot population in Tamaulipas. Habitat protection can include conservation easements or fee title acquisition from willing sellers. Creation of a Bi-national Coastal Wildlife Corridor from LANWR, Cameron County, Texas to the Laguna Madre y Delta del Rio Bravo National Natural Protected Area in Tamaulipas, Mexico has been identified as a shared goal of the USFWS and CONANP. This corridor should be at least 0.25 mile wide and provide habitat connectivity from the Cameron County ocelot population at LANWR in Texas to the northernmost known ocelot population in Tamaulipas.

1.2.3.5. Protect habitat in other portions of the historic range in Arizona, Texas, Sonora, and Tamaulipas. Where feasible, remaining habitat in southern Arizona, Sonora, Texas, and Tamaulipas should be protected through partner agreements, conservation easements or fee title acquisition from willing sellers.

1.2.4. Restore thornscrub habitat.

1.2.4.1. Develop methodologies for thornscrub restoration. Small scale experiments have demonstrated that some aspects of thornscrub can be restored relatively quickly on suitable soils. However, such efforts have not resulted in the measurable expansion of ocelot habitat or the restoration of landscape connectivity. Monitoring should continue on existing restoration sites, and new methodologies should be developed that encourage the species diversity and structure that constitute occupied ocelot habitat in Texas.

1.2.4.2. Identify and map appropriate soils for thornscrub restoration. Suitable ocelot habitat in Texas is associated with soils that are also desirable for agricultural uses. Existing soil maps should be available and useful in identifying potential habitat restoration zones. The selection of specific restoration areas should be a function of their potential to serve as occupied breeding habitat and travel corridors that link currently disjunct tracts of occupied or potential habitat. The re-establishment of thornscrub habitat in appropriate locations and spatial configurations will facilitate colonization by ocelots.

1.2.4.3. Restore thornscrub habitat around core ocelot populations in Texas. In Willacy County, at least 2,000 acres of thornscrub habitat around existing, occupied habitat should be restored through invasive grass control and planting native seedlings. In Cameron County, at least 1,000 acres of thornscrub habitat around existing, occupied habitat on LANWR should be restored through invasive grass control and planting native seedlings.

1.2.4.4. Implement thornscrub restoration on a priority basis to benefit ocelots. Restoration habitat should be prioritized according to its proximity to occupied range, its ability to serve as occupied range, and its utility as a landscape linkage between occupied areas, and its suitability with regard to soils and water regimes. Thornscrub retention should be encouraged with landowners whenever possible, e.g., when irrigation ditches are being converted to underground water delivery systems.

1.2.4.5. Develop and implement a monitoring program for restored thornscrub. The rate of recovery, growth, and spread of restored thornscrub should be systematically monitored and the information used to adapt and improve restoration methodologies.

1.2.5 Assure available drinking water during periods of drought. Identify strategic well sites and install solar-powered pumps to provide assured water during dry years. Also, restore freshwater wetlands.

1.3. Determine the status, trends, ecology, and threats to ocelots in the ASMU.

1.3.1. Refine current distribution map of the regional population. Greater precision concerning ocelot presence, numbers, and specific habitat requirements will enable biologists and managers to establish the most efficient approaches to ocelot conservation, management, and recovery.

1.3.1.1. Map existing habitat potentially suitable for supporting ocelots in Sonora and Arizona. Incorporate satellite data, topographic maps, and elevation maps into GIS to estimate land cover throughout the region and determine suitable habitat. Identify areas that could provide corridors for movement between Sonora and Arizona.

1.3.1.2. Continue and expand surveys to document the presence of ocelots in known and potential habitat. Presence/absence surveys and systematic field monitoring are needed to determine the current status and distribution of the ocelot in ASMU. Field data will be combined with GIS data to extrapolate the location and abundance of potential ocelot populations in Sonora and Arizona.

1.3.1.3. Establish a minimum of three long-term monitoring areas in Sonora and Arizona. This information will provide baseline population data (with small confidence intervals) to detect population trends and establish whether recovery criteria are met.

1.3.1.4. Identify existing and proposed conservation lands in current and potential ocelot range in Sonora and Arizona. Property boundaries, and state and Federal lands in Sonora and Arizona need to be incorporated into GIS models to understand the spatial configurations of conserved areas and preferred ocelot habitats. Land of property owners willing to support ocelot recovery and would be incorporated into the model.

1.3.2. Determine spatial requirements of ocelot populations in Sonora and Arizona.

1.3.2.1. Conduct GPS telemetry studies and other noninvasive monitoring to determine habitat selection. An understanding of habitat use in core areas and peripheral areas, especially in northern Sonora, will assist with calculating the quantity and quality of habitat required to support viable ocelot populations.

1.3.2.2. Determine daily and seasonal movements, including patterns of subadult dispersal. GPS telemetry data complemented with track/scat transects will aid in providing home range size, travel routes, and connectivity between core areas and peripheral habitats.

1.3.2.3. Identify conduits and barriers to movements. Studies of vegetation types, degree of cover, topography, water distribution, in conjunction with ocelot presence and repeated use will reveal habitat linkages important to ocelot dispersal. After these corridors are identified, ocelots can be monitored and barriers to movement can be detected and managed.

1.3.2.4. Identify food habits, prey preferences, prey abundance and distribution. As ocelots tend to be found where there is adequate vegetative cover and prey, an analysis of the quantity of prey needed in conjunction with the location of favored prey species is a valuable predictor suitable ocelot habitat.

1.4. Identify significant threats to ASMU populations. The extent to which habitat loss is affecting ocelots in Sonora or Arizona should be determined. Increasing border activity, human population growth and its accompanying development may be decreasing and fragmenting available habitat.

1.5. Identify mechanisms to reduce or alleviate significant threats to ASMU populations. As understanding of the scope and significance of threats to the ASMU are identified, corresponding solutions should be developed to protect habitat and promote conservation and recovery.

2. Reduce the effects of human population growth and development on the ocelot.

2.1. Avoid, reduce, and minimize impacts of roads and bridges to the ocelot.

2.1.1. Quantify the effects of roads and bridges on habitat suitability and determine road density threshold for ocelots. Noss and Cooperrider (1994) observed that “Open road density has been found to be a good predictor of habitat suitability for large mammals, with habitat ‘effectiveness’ and population viability declining as road density increases.” The relation between roads and ocelot presence needs better quantification to determine thresholds of tolerance. This information can be obtained by examining the distribution of occupied and unoccupied tracts of thornscrub and other appropriate habitats and comparing structural characteristics that are related to highways and bridges such as nearness to traffic, traffic noise, traffic levels, and daily patterns of vehicle use.

2.1.2. Identify optimal locations for crossing structures. This should incorporate ocelot density and movement data from radio telemetry, camera studies, live trapping, dens, scats, tracks, road kills, and digital land cover analysis from ongoing field studies.

2.1.3. Identify design specifications for crossing structures and other features to reduce mortality. Examples from Europe, Florida, and the western U.S. should serve as preliminary models for ocelot-specific designs (Forman et al. 2003). Designs should also incorporate ocelot behavioral information (i.e., aversion to open areas). Appropriate vegetation should be maintained around crossing areas to shield and funnel ocelots to crossing structures, or in some cases, integrate fencing with crossing structures.

2.1.4. Engage Federal and state departments of transportation in ocelot conservation.

2.1.4.1. Support participation in interagency planning to conserve ocelots. Coordination, including section 7 consultations and other mechanisms, between wildlife management agencies and transportation departments is critical to implementation. The participation of representatives from these departments on the ocelot Recovery Team Implementation subgroup and local working groups should be cultivated and supported.

2.1.4.2. Avoid, reduce, and minimize the impacts of new roads and bridges in ocelot habitat and corridors. Good coordination among agencies, as described above, will assist in genuine assessment of possible alternatives to or mitigation of construction of new roads and bridges in prime ocelot habitat through preplanning of route adjustment, maximum retention or restoration of vegetation, and strategic location of crossing structures.

2.1.4.3. Where new roads or bridges are unavoidable, implement crossing structures and other appropriate designs to minimize road mortality and habitat loss. Information from ocelot monitoring data and vegetation mapping should be used to include crossing structures in new road and bridge construction where appropriate. In ocelot habitat, crossing structures should be built where new roads or bridges bisect natural landscape pathways such as drainages.

2.1.4.4. Construct new crossing structures or other design features on existing roads and bridges to reduce mortality in areas of heavy ocelot use. A minimum of 10 crossings should be constructed at key locations, including Highway 77 (I-69), Highway 186, FM106, FM510, Highway 100, Highway 4, and Highway 281. Information from monitoring data and design development (Recovery Actions 2.1.1 and 2.1.3) should be used to prioritize and construct crossing structures on existing roads to reduce ocelot mortality.

2.2. Avoid, reduce, and minimize U.S.-Mexican border infrastructure, maintenance, and development impacts on ocelot habitat and behavior.

2.2.1. Identify and communicate strategic locations for ocelot border crossings. This will require the application of knowledge about ocelot habitat requirements and dispersal behavior, and the mapping information developed for the model in Recovery Actions 1.1.1 – 1.1.10.

2.2.2. Design border-associated structures and activities to address necessary border security and facilitate cross border movements by ocelots. Coordination through NEPA and other procedures with agencies on both sides of the border is needed to affect changes in current use and management of borderlands structures and activities. Minor modifications to planned or existing structures such as maintaining natural vegetation (especially thornscrub or structurally similar vegetation) under bridges, around dams, within power line corridors, or beside roads can provide opportunities for ocelot travel and discourage illegal human travel. When dredging occurs, spoil should be placed where it will not block shore access or river crossings by ocelots. Lighting should be minimized in strategic ocelot crossing locations and pointed away from dense woody vegetation. Openings large enough to allow for the passage of ocelots should be incorporated into existing and planned border fences in ocelot habitat, such as has been done in some areas in Texas.

2.2.3. Maintain and enhance thornscrub habitats or similar vegetative structure near the border. Thornscrub and structurally similar habitats along border riparian zones are especially important to encourage river crossings and provide year-round access to water. Fires set by patrolling vehicles or illegal immigrants and other associated activities along the border sometimes destroy thornscrub and structurally similar habitat. However, dense thornscrub or structurally similar habitat may be a deterrent to illegal border crossings by humans, making its maintenance or restoration potentially attractive to enforcement authorities. Communication and relationship development with enforcement authorities, as described in Recovery Actions 2.1.4 and 2.3.2 are critical to making progress in this area.

2.3. Avoid, reduce, or minimize impacts from other development projects and human activities, including residential and commercial construction, wind farms, and other developments and activities in ocelot habitat or corridors. Partnerships and collaboration between wildlife management agencies and private landowners, developers, irrigation and drainage districts, utility companies, and other entities should be cultivated in order to promote preservation of and reduce impacts to ocelot habitat and corridors. Section 7 consultations and other mechanisms should be used to ensure impacts are minimized or avoided. Where feasible, agreements to protect a corridor of habitat along one side of irrigation and drainage ditches should be developed to protect ditch habitat corridors used by ocelots.

3. **Maintain or improve genetic fitness, demographic conditions, and health of the ocelot in borderland populations.**

    3.1. Maintain or increase genetic diversity within core populations.

    3.1.1. Monitor genetic health and diversity in Texas ocelot populations; evaluate genetic augmentation. Reduced genetic diversity in Texas is a threat. Analysis of the Texas populations should continue to assess its status and track progress towards recovery as translocations occur and as the population grows. Tissue samples collected during routine capture activities and the use of hair collected from baited hair snares can provide the samples necessary for standard protocols to track genetic changes in the population. The genetic augmentation plan should include a monitoring protocol for evaluating results and appropriate adaptive management. The protocol will include monitoring of microsatellites, specifically for levels of heterozygosity and allele diversity, and mitochondrial cytochrome-b haplotypes. Both source and recipient populations will be evaluated prior to translocation. After translocation, monitor recipient populations for multiple generations.

    3.1.2. Monitor genetic health and diversity in Tamaulipas populations; evaluate genetic augmentation. Research and monitoring of ocelots in Tamaulipas should include genetic studies, including microsatellite diversity and mitochondrial cytochrome-b haplotypes analyses, to establish and track the genetic structure and stability of translocation source populations and determine the efficacy of any translocation programs to augment populations in Texas.

    3.1.3. Characterize the genetic status and variability of the ocelots Sonora. Although the ocelot populations in Arizona/Sonora and those of Texas/Tamaulipas are considered separate subspecies, the genetic variability between the two ocelot populations is unknown, as is the genetic diversity within the Arizona/Sonora population. This information could assist in management of borderland populations.

    3.1.4. Design a genetic and population augmentation program and protocols for core populations as necessary. PVA analysis (Appendix IV; Haines et al. 2005a) have indicated that LANWR and Kenedy -Willacy ocelot populations have limited gene diversity and would benefit from augmentation from Tamaulipas ocelots. A cooperative plan between Mexico and the U.S. should be developed with the oversight of the Recovery Team to address both genetic and population augmentation.

    3.1.5. Evaluate the need and feasibility of artificial reproductive techniques to manage genetic diversity; if appropriate, implement techniques for and develop of a genetic gamete tissue bank program. Artificial reproduction techniques such as artificial insemination may be an alternative or supplement to translocation to improve genetic structure of the population. Developing a gamete tissue bank will organize and maintain frozen samples and broaden options for genetic enhancement.

3.1.6. Evaluate the need and efficacy of establishing a captive breeding program. Ocelots are well represented in zoos and much is known about their husbandry. Resources at appropriate zoos should be examined to determine the feasibility of expanding numbers of wild-captured or captive animals of known origin in zoological parks to be used in genetic augmentation and for reintroduction. However, at this time, no wild animals should be removed from Texas populations to augment a captive population. Any captive breeding program should be explicitly organized to support and not replace *in situ* conservation (Snyder et al. 1996).

3.2. Increase the number of ocelots in core populations as necessary.

3.2.1. Conduct experimental translocations. Once a plan has been developed (see Recovery Action 3.1.3), conduct experimental translocations to evaluate and refine techniques as necessary. Capture and translocation methodology and the characteristics (such as age and sex) of ocelots that contribute to successful translocation should be evaluated.

3.2.2. Augment existing populations as necessary through translocation. If suitable habitat exists near core areas that are currently unoccupied, ocelots may be translocated to improve demographic and genetic stability.

3.2.3. Evaluate the feasibility of using confiscated ocelots to augment populations. If the subspecific origin of individuals can be determined and they are sufficiently healthy, such animals should be considered for supplementation of captive populations.

3.3. Identify an area for establishing a new ocelot population within the historic range in Texas. The potential for establishing additional ocelot populations in Texas should be thoroughly evaluated. Additional populations would enhance recovery of the ocelot by reducing the loss of genetic variability and by spreading the extinction risk to multiple units that are geographically and therefore demographically independent. Within the U.S. Fish and Wildlife Service's National Wildlife Refuge System, ocelots are known to occur on Laguna Atascosa NWR and conservation easements of Lower Rio Grande Valley NWR. Aransas NWR may have potential as a reintroduction site, and the Lower Rio Grande Valley and Santa Ana NWRs historically supported ocelots and are important links to Mexico. However, these refuges currently exist in denatured landscapes and the potential for existing and future occupation by the ocelot has not been thoroughly investigated. Evaluation of the potential for reintroduction would include a thorough NEPA analysis to determine relevant biological factors as well as social, environmental, and economic impact analyses.

3.4. If an area suitable for a new ocelot population is identified, establish a new population within historic range in Texas. Social acceptance of reintroduction is critical to success of the effort and to building tolerance and support for endangered species. If ocelots are reintroduced on public lands, the surrounding private landowners must be engaged and assured of protection from real or perceived liability from endangered species. Introduction of a non-essential experimental population would be appropriate if the reintroduced population is geographically separated from ocelots with fully endangered status at the time of introduction. A special rule under section 4(D) of the ESA could be written to provide flexibility of management which would apply to all ocelots within the experimental population area boundary.

3.5. Protect ocelots from life threatening diseases, parasites, and injuries.

3.5.1. Establish protocols for physiological assessment and individual identification. For all ocelots handled, collect physical data reflecting health and reproductive status (e.g., gender, weight, body measurements, age, body temperature, pulse, respiration, and overall condition). Photographs of each individual will be taken to record distinguishing patterns and other unique features and passive integrated transponder (PIT) tags should be injected under the skin between the shoulder blades for permanent identification.

3.5.2. Conduct serology and pathology surveys to determine genetic profile, overall condition, and the presence and effect of diseases and parasites. Blood, hair, urine, and fecal samples (as possible) will be collected antiseptically by experienced researchers to document genetic status, disease, parasites, hormone levels, and general health of captured or injured ocelots.

3.5.3. Create a tissue bank for ocelot samples. A tissue bank would maintain samples for reference and future study. A list of what samples to collect, how to collect them, where to store samples, and other useful data will standardize data collection and proper storage.

3.5.4. Establish protocols for treatment of injury, diseases, and parasites as appropriate. Specific to each type of condition, treatment protocols may bring more rapid and efficient assistance to ailing ocelots and can give field researchers guidance for administering ocelot first aid should immediate assistance be required.

3.5.5. Establish a database of medical and genetic ocelot data. A computer database containing health, identity, and treatment information from captured or injured ocelots will help to maintain a record of each ocelot's condition. A standardized, long-term database will allow the detection of trends, predictions, and will facilitate recovery. Links to protocol procedures and equipment lists will be included.

3.5.6. Investigate measures to prevent disease. The efficacy of preventative measures, such as vaccinations vs. biological methods, such as controlling vectors of disease, needs to be investigated. Killed-virus rabies vaccines have been given to captured ocelots since 1995 and this practice should be continued.

3.6. Identify and reduce the impacts of environmental contaminants on the ocelot.

3.6.1. Conduct research that identifies pathways of contamination in ocelots and their prey and provides solutions to existing toxicity problems. Evaluate the effects of rodenticides, crop-spraying, water contamination, and bioaccumulation on ocelots and their prey. This will include an examination of the physiological effects of these toxins on the ocelot, the differences in pesticide usage in the U.S. and Mexico, and recommendations for solving the problems revealed in this research.

3.7. Investigate competitive interactions among the bobcat, coyote, and ocelot.

3.7.1. Conduct field studies designed to explicate the degree of niche overlap between the ocelot and its potential competitors. Studies that are targeted at such relationships are warranted. A better understanding of the interactions between the ocelot and competitors will be important in the evaluation of habitat management targeted at improving landscape conditions and recovery potential for the species. Continue to document food habits and direct interactions between individuals of all three species. Consider conducting experiments whereby bobcats and coyotes are removed from ocelot home ranges.

4. Assure the long-term success of ocelot conservation through partnerships, landowner incentives, community involvement, application of regulations, and public education and outreach.

4.1. Develop partnerships with other agencies, organizations, and citizens.

4.1.1. Develop regional recovery working groups that practice broad-based community planning for ocelot conservation. Implementation of recovery actions for the ocelot throughout its range are necessary. However, breaking down the tasks with a regional or local focus makes recovery more manageable and feasible. Working groups with a membership and focus on locally important issues in U.S. and Mexico should be formed as a function of the Implementation Subgroup of the Recovery Team, and encouraged and supported by the USFWS over the long term. Because funding for recovery is a significant challenge, each working group should consider establishing a funding coordinator to ensure viability of local recovery efforts. Many agency and private programs, grants, and foundations are available to assist in recovery efforts.

4.1.2. Continue momentum for recovery through the implementation and technical subgroups of the Recovery Team. The Ocelot Recovery Team Implementation Subcommittee should function as an oversight body for the implementation of the recovery plan. A system of communication among working groups, the Technical Team, and the USFWS should be implemented through periodic reporting or meetings so that adaptive management can be used to support their efforts, track recovery, and modify the plan as necessary.

4.1.3. Restore and protect habitat through cooperative conservation projects such as Safe Harbor Agreements, Habitat Conservation Plans, acquiring key property through easements or fee title with willing landowners on non-Federal lands in the U.S. One of the primary roles of the USFWS in recovery is to assure that appropriate resources and tools for partnership implementation are understood and available to its partners. Because of the significant amount of private lands essential to ocelot recovery, the USFWS should be vigilant in making such resources available that support projects with willing landowners.

4.1.4. Develop other incentive programs with landowners who have existing brush or who want to restore thornscrub habitat on non-Federal lands in the U.S. Incentives need to be developed for landowners to encourage them to maintain existing thornscrub habitat and to restore habitat where it was previously cleared. A system of communication between local working groups and the USFWS is essential to identify opportunities, work with local people, and provide the appropriate technical or financial support.

4.1.5. Support work by biologists in Mexico to survey existing and potential habitat. Resources, including funding and technical support will be essential to assuring that information regarding the ocelot in Tamaulipas and Sonora is obtained and shared. Local communities will benefit and generate more interest if resources are made directly available to Mexican biologists.

4.1.6. Develop partnerships with Mexican agencies and landowners to implement recovery actions. Ocelot conservation in Mexico is fundamental to recovery for the ocelot in the U.S. A working group for transborder and Mexico issues should be formed to develop partnerships, research incentives, and find support for recovery and conservation in Mexico. Continued support of Mexican partners on the Ocelot Recovery Team will be key to coordination of these actions.

4.1.7. Encourage participation of the Department of Homeland Security and the Border Patrol with agencies responsible for ocelot conservation. It is important to develop relationships with DHS and CBP to assure that conservation needs of ocelots are considered within the context of the charges and missions of the CBP, DHS, and the USFWS. Collaborations among agencies will minimize potential conflicts and enable Federal agencies to balance the needs of immigration policies and wildlife conservation.

4.2. Protect the ocelot by using or developing regulations where necessary.

4.2.1. Encourage development and enforcement of regulations in Mexico to protect ocelots. Technical assistance and conservation recommendations should be made available to Mexican authorities. Although national and international laws exist to protect the ocelot in Mexico, funding is insufficient for effective enforcement. Because ocelot harvest is likely only a local problem, the Mexican government should be encouraged to protect areas where ocelots are present.

4.2.2. Assure compliance with existing regulations for oil and gas development and seismic exploration that could negatively affect the ocelot. Through section 7 compliance and other means, the USFWS should lead efforts to coordinate with other regulatory agencies and developers to promote activities that would not constrain movement of ocelots or alter potential ocelot habitat. Use mitigation opportunities to enhance ocelot habitat.

4.3. Expand education and outreach to promote ocelot conservation.

4.3.1. Maintain an education/outreach working group under the Ocelot Recovery Team Implementation Subgroup to coordinate efforts for the ocelot. Outreach and education are crucial and should be performed at all levels of the recovery effort, including interactions with private landowners by researchers and managers, education in schools, outreach to hunters, non-government organizations (NGO), and legislators. Many current members of the Recovery Team have expertise, and work in environments that have resources for outreach. Zoos, NGOs, Universities, USFWS, state agencies, and other partners should collaborate in a working group to coordinate outreach and assist in implementation efforts. Many outreach materials and efforts will need to have a local focus and purpose; therefore, frequent interaction between outreach and regional working groups is important. Materials will be provided in both Spanish and English.

4.3.2. Develop a regional outreach plans for the TTMU and ASMU. An education and outreach program will create additional landowner participation in ocelot conservation, raise public awareness, build advocacy and support, and help generate human behavioral changes that will abet ocelot conservation.

4.3.2.1. Develop education materials and plans for Texas and Arizona. An outreach plan should identify and cultivate the most effective partners and audiences and develop targeted educational materials. Development of materials should consider what may motivate the public to get involved with or support the recovery effort, and promote such incentives. Involving a marketing specialist in the development of a plan is advised. All possible venues, including websites, interconnectivity of web links, list server messages, paper, film and other media should be considered.

4.3.2.2. Develop education materials and plans for Tamaulipas and Sonora. Efforts and audiences in Mexico will be different from those in the U.S. and may require a different strategy. An education and outreach specialist from Mexico should be cultivated for the Implementation Team and working group to assure the effort is effective.

4.3.3. Monitor and assess the effectiveness of outreach efforts. To the extent possible, methods for monitoring the effectiveness of outreach strategies should be built into the outreach plans. The working group should seek funding for appropriate research or survey work to monitor and adapt the effort as necessary.

4.3.4. Educate hunters, landowners, and predator control personnel to recognize ocelots and refrain from killing them. Hunter education programs should be promoted by state wildlife agencies to prevent accidental shooting. Brochures (in both Spanish and English) with basic information and identification keys should be distributed to landowners, hunters, and predator control agents at appropriate venues.

5. Practice adaptive management in which recovery is monitored and recovery tasks are revised by USFWS in coordination with Recovery Team subgroups as new information becomes available.

5.1. Develop a monitoring schedule and protocol for core populations. To track progress for recovery, population monitoring must be regular, thorough, and standardized. Funding for monitoring by researchers and USFWS in both Texas and northern Mexico should be a priority. A monitoring protocol that utilizes remote-activated cameras was described by Grassman et al. (2006).

5.2. Develop agreements with willing landowners to survey for and monitor populations and habitats on non-Federal lands. The lack of information about ocelot populations on private lands is a major impediment to its recovery. Developing landowner trust and cooperation is essential. The Technical and Implementation Subgroups of the Recovery Team should work closely together to develop and implement strategies to involve landowners, build trust, and encourage information sharing.

5.3. Conduct monitoring. Monitoring on public lands and private lands as landowner agreement is gained should be a high priority and conducted with standardized protocols. Monitoring of core populations should be increased.

5.4. Prepare annual reports of ocelot monitoring results. Monitoring data should be compiled and provided to the USFWS and Recovery Team annually to track progress towards recovery. Monitoring data at the scale of country and ocelot population segment should be compiled and provided to the Recovery Team annually to track progress toward recovery.

5.5. Develop cooperation among agencies and organizations for data sharing and data repository. Cooperation and communication among all the partners working towards recovery of the ocelot is essential to success. Population data should be regularly shared with the Recovery Team so that the status of the ocelot, progress towards recovery, and necessary adjustments to planning and implementation efforts are made. Data should be reported at a scale that protects landowner privacy and proprietary rights to original data while conveying needed biological and management information. Building trust with landowners and assuring the protection of unpublished research data is fundamental to achieving this action.

6. Support efforts to ascertain the status and conserve ocelot populations south of Tamaulipas and Sonora.

6.1. Track locations of skins to determine source of illegal harvest. Genetic markers exist that can be used to pinpoint source populations using specific alleles. The collection and assessment of ocelot genetic information from different countries and their unique genetic markers can be used to compare to those of illegally obtained pelts to determine the location of harvest.

6.2. Promote data collection and sharing among countries with ocelots.

6.2.1. Provide support for a routine workshop every three to five years to gather ocelot information. Seek financial resources to bring IUCN Cat Specialist Group together with the Ocelot Recovery Team and other researchers to share data and ideas. Such a meeting would provide a forum for information exchange to assess the status, address research, education, and conservation needs for ocelots.

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6.2.2. Support efforts of international conservation groups to implement the Meso-American corridor (formerly the Paseo Pantera Corridor). The Ocelot Recovery Team will assist land and resource managers from any interested nations with developing guidelines for habitat conservation and the preservation of key linkages, such as those involved in the Meso-American corridor. This is to ensure that the ocelot's current and future needs for natural dispersal are addressed.

6.3. Coordinate recommendations and available genetic data from international zoos. Zoos are a valuable source of ocelot reproduction, food requirements, and habitat conditions. Much information of ocelot genetics and habits comes from zoo studies. Establishing a link within the ocelot database of the future that provides rearing and genetic information may be helpful for global monitoring of ocelot genetic diversity and might assist with the care of captive ocelots.

3.0 IMPLEMENTATION SCHEDULE

The following implementation schedule outlines priorities, potential or responsible parties, and estimated costs for the specific actions for recovering the ocelot. It is a guide to meeting the goals, objectives, and criteria from Section 2 RECOVERY of this recovery plan. The schedule: (a) lists the specific recovery actions, corresponding outline numbers, the action priorities, and the expected duration of actions; (b) recommends agencies or groups for carrying out these actions; and (c) estimates the financial costs for implementing the actions. These actions, when complete, should accomplish the goal of this plan – recovery of the ocelot.

3.1 Responsible Parties and Cost Estimates

The value of this plan depends on the extent to which it is implemented; the USFWS has neither the authority nor the resources to implement many of the proposed recovery actions. The recovery of the ocelot is dependent upon the voluntary cooperation of many other organizations and individuals who are willing to implement the recovery actions. The implementation schedule identifies agencies and other potential "responsible parties" (private and public) to help implement the recovery of this species. This plan does not commit any "responsible party" to carry out a particular recovery action or to expend the estimated funds. It is only recognition that particular groups may possess the expertise, resources, and opportunity to assist in the implementation of recovery actions. Although collaboration with private landowners and others is called for in the recovery plan, no one is obligated by this plan to any recovery action or expenditure of funds. Likewise, this schedule is not intended to preclude or limit others from participating in this recovery program.

The cost estimates provided are not intended to be a specific budget but are provided solely to assist in planning. The total estimated cost of recovery, by priority, is provided in the Executive Summary. The schedule provides cost estimates for each action on an annual or biannual basis. Estimated funds for agencies included only project-specific contract, staff, or operations costs in excess of base budgets. They do not include ordinary operating costs (such as staff) for existing responsibilities.

3.2 Recovery action priorities and abbreviations

Priorities in column 1 of the following implementation schedule are assigned using the following guidelines:

Priority 1a = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 1b = An action that by itself will not prevent extinction, but which is needed to carry out a Priority 1a action.

Priority 2 = An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction.

Priority 3 = All other actions necessary to meet the recovery objectives.

The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

The following abbreviations are used in the Implementation Schedule:

ADOT = Arizona Department of Transportation
AGFD = Arizona Game and Fish Department
AZA = Association of Zoos and Aquariums
CBP = U.S. Customs and Border Protection
CKWRI = Caesar Kleberg Wildlife Research Institute
DHS = Department of Homeland Security
DOW = Defenders of Wildlife
DZ = Dallas Zoo
ED = Environmental Defense
GPZ = Gladys Porter Zoo
IBWC = International Boundary and Water Commission
IEA = Instituto de Ecologia y Alimentos
NAT = Naturalia
PL = Private Landowners
PRNA = Pronatura
SCT = Secretaría de Comunicaciones y Transportes
SEM = La Secretaría de Medio Ambiente y Recursos Naturales (SEMERNAT)
TNC = The Nature Conservancy
TPWD = Texas Parks and Wildlife Department
TxDOT = Texas Department of Transportation
UA = University of Arizona
UNAM = Universidad Nacional Autónoma de México (National Autonomous University of Mexico)
USDOT = U.S. Department of Transportation
USFWS = U.S. Fish and Wildlife Service

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
1b	1.1.1	Map existing and suitable brushlands in Texas	2	A	1	USFWS, TPWD, ED	YES	70	70							Remotely sensed - 1 Temp FTE - Limited to 8 counties in south Texas - 250/man day @250 days - 7,500 travel and equip related expenses
1b	1.1.2	Map existing and suitable brushlands in Tamaulipas	2	A	7	USFWS, IEA, PRNA, SEM	YES									
1b	1.1.3	Document ocelot's status in known and potential habitat in Texas	2	A	7	CKWRI, USFWS, TPWD	NO	470	65	65	65	65	70	70	70	
1b	1.1.4	Document ocelot's status in known and potential habitat in Tamaulipas	2	A	7	CKWRI, USFWS, PRNA, SEM	NO	400	55	55	55	55	60	60	60	
1b	1.1.5	Estimate area for 200 ocelots in Texas and 1,000 in Tamaulipas	2	A,E	1	CKWRI, USFWS, PRNA, SEM	NO	15		15						
2	1.1.6	Identify conservation lands in TTMU range	2	A,E	1	CKWRI, ED, USFWS, PRNA, SEM, TNC	YES	15		15						
2	1.1.7	Identify, field verify, and map connections between TTMU populations	2	A	1	CKWRI, USFWS, PRNA, SEM	YES	25			25					
2	1.1.8	Study ocelot dispersal behavior	1,2,3	A,E	4	CKWRI, USFWS, PRNA, SEM	NO	210	60	50	50	50				
2	1.1.9	Develop computer simulations of ocelot movement and dispersal	1,2,3	A,E	4	CKWRI, USFWS, PRNA, SEM	NO	160	45	40	40	35				

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
2	1.1.10	Identify and prioritize lands for habitat restoration	2,3	A	1	CKWRI, ED, USFWS, PRNA, SEM, TPWD	NO	25	25							
1b	1.1.11	Identify habitat linkages and necessary crossing structures in south Texas and Arizona	2	A,E	3	CKWRI, ED, USFWS, PRNA, SEM, TPWD, TxDOT, USDOT	NO	9	3	3	3					Done in conjunction with map existing habitat - amt is additional required
3	1.2.1	Develop, distribute, and implement habitat guidelines	1,2,3	A	1	ED, USFWS, TPWD	NO	20	20							
2	1.2.2	Foster partnerships with landowners	1,2,3	A,E	7	AGFD, CKWRI, USFWS, IEA, PRNA, SEM, TPWD, ED	NO	45	10	10	5	5	5	5	5	TPWD has ongoing efforts by Tech guidance biologist to foster partnerships with landowners
2	1.2.3.1	Protect habitat in and around known populations	1,2,3	A	7	USFWS, ED, PRNA, SEM, TNC, TPWD	YES	7000	1000	1000	1000	1000	1000	1000	1000	Includes protection through both fee title and conservation easements
2	1.2.3.2	Create a corridor connecting Texas populations	1,2,3	A	7	USFWS, ED, TNC, TPWD	YES	1050	150	150	150	150	150	150	150	Includes protection through both fee title and conservation easements
2	1.2.3.3	Protect habitat in recently occupied areas	1,2,3	A	7	AGFD, ED, USFWS, PRNA, SEM, TNC, TPWD	YES	10000	1600	1600	1600	1600	1600	1000	1000	Includes protection through both fee title and conservation easements
2	1.2.3.4	Create a bi-national corridor connecting Texas and Tamaulipas populations	1,2,3	A	7	USFWS, ED, PRNA, SEM, TNC, TPWD	YES	11200	1600	1600	1600	1600	1600	1600	1600	Includes protection through both fee title and conservation easements

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
2	1.2.3.5	Protect habitat within historical range in Arizona, Texas, Sonora, and Tamaulipas	1,2,3	A	7	AGFD, ED, USFWS, PRNA, SEM, TNC, TPWD	YES	1700	200	250	250	250	250	250	250	Includes protection through both fee title and conservation easements
3	1.2.4.1	Develop methods to restore thornscrub	2	A		CKWRI, USFWS, TPWP	NO	175		50	45	45	35			
3	1.2.4.2	Identify and map soils for thornscrub restoration	2	A	1	CKWRI, USFWS, PRNA, TPWD	YES	31	31							
3	1.2.4.3	Restore thornscrub around core populations in Texas	2	A	7	USFWS, TNC, PL, ED	YES	1785	255	255	255	255	255	255	255	
3	1.2.4.4	Implement thornscrub restoration in other areas	2	A	7	DOW, ED, USFWS, PL, TNC, TPWD, TxDOT	NO	1750	250	250	250	250	250	250	250	Estimate plant 250 acres/year @400 seedlings/acre to establish 200 seedlings/acre live after 1 year - assume a price of $2/seedling - 50,000 annually for site prep etc.
3	1.2.4.5	Develop and implement a monitoring program for restored thornscrub	2	A	7	CKWRI, ED, USFWS, TPWD	NO	15	2	1	1	2	2	4	3	250/man day @ varying number days depending on number of restoration sites to analyze
2	1.2.5	Assure available drinking water during periods of drought	2	E	5	USFWS, EDF, TNC, TPWD	YES	215	43	43	43	43	43			Identify well sites, build guzzlers, intall solar-powered pumps

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s) 2010	2011	2012	2013	2014	2015	2016	Comments
2	1.3.1.1	Map existing habitat suitable for ocelots in Sonora and Arizona	3	A	1	AGFD, USFWS, PRNA, SEM	NO	200	100	100						Staff GIS person, data entry, analysis, modeling, reviewing
2	1.3.1.2	Continue and expand surveys in ASMU habitat	3	A,E	7	AGFD, USFWS, SEM	NO	350	50	50	50	50	50	50	50	Field work, data management
3	1.3.1.3	Establish at least 3 long-term monitoring areas in Sonora and Arizona	3	A,B,D, E	6	SEM, AGFD, USFWS	NO	1200		200	200	200	200	200	200	GPS collars, collar maintenance, staff
2	1.3.1.4	Identify conservation lands in ASMU range	3	A	2	AGFD, USFWS, SEM	NO	50			25			25		
3	1.3.2.1	Determine habitat selection in Sonora and Arizona	1,2,3	A,B,C, D,E	5	SEM, AGFD, USFWS	NO	1000	200	200	100	200	200	100		Survey methodology, field data, staff; combine with 1.3.1.3, 1.3.2.2., 1.3.2.3.
3	1.3.2.2	Determine movements and sub-adult dispersal in Sonora and Arizona	1,2,3	A,E	3	SEM, AGFD, USFWS	NO	750		250		250		250		Field work; combine with 1.3.1.3, 1.3.2.2., 1.3.2.3
2	1.3.2.3	Identify conduits and barriers to movements in Sonora and Arizona	1,2,3	A,E	3	AGFD, USFWS, SEM	NO	150		50		50		50		GIS, field work; combine with 1.3.1.3, 1.3.2.2., 1.3.2.3
3	1.3.2.4	Identify food habits and prey preference, abundance, and distribution in Sonora	1,2,3	A,E	5	SEM	NO	500	100	100	100	100	100			Collars, field work, data management; combine with 1.3.1.3, 1.3.2.2., 1.3.2.3
2	1.4	Identify significant threats to ASMU populations	3	A,B,C, D,E	3	AGFD, USFWS, SEM	NO	150		50		50		50		Staff salary in combination with 1.3. actions
2	1.5	Identify mechanisms to reduce and alleviate threats to ASMU	3	A,B,C, D,E	3	AGFD, CBP, USFWS, SEM	NO	150		50		50		50		Staff salary in combination with 1.3. actions

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
1b	2.1.1	Quantify road and bridge effects on habitat suitability; determine ocelot road density threshold	2	A,E	4	CKWRI, USFWS, TPWD, TxDOT, USDOT	YES	205	60	50	50	45				
1a	2.1.2	Identify optimal locations for road crossing structures	2	A,E	2	CKWRI, USFWS, TPWD, TxDOT, USDOT	YES	30	15	15						
1a	2.1.3	Identify design specifications for crossing structures and other mortality-reducing features	2	A,E	1	CKWRI, TxDOT, USDOT	NO	15	15							
1a	2.1.4.1	Support participation in interagency planning to conserve ocelots	1,2,3	A,B,C, D,E	ongoing	AGFD, USFWS, SCT, TPWD, TXDOT, USDOT	YES	70	10	10	10	10	10	10	10	
1a	2.1.4.2	Minimize impacts of new roads and bridges in ocelot habitat	2,3	A,E	7	ADOT, USFWS, SCT, TPWD, TXDOT	NO	105	15	15	15	15	15	15	15	Predicted consultation costs
1a	2.1.4.3	Implement crossing structures and designs	2,3	A,E	ongoing	ADOT, USFWS, SCT, TPWD, TXDOT, USDOT	NO	70	10	10	10	10	10	10	10	Ongoing
1a	2.1.4.4	Construct new crossing structures in heavy use areas	2	A,E	ongoing	ADOT, USFWS, SCT, TPWD, TXDOT, USDOT	NO	11900	1700	1700	1700	1700	1700	1700	1700	Ongoing; based on two crossings per year
1b	2.2.1	Identify locations for ocelot border crossings	2,3	A,E	1	CKWRI, USFWS, PRNA, SEM	YES	40	10		10		10		10	
1b	2.2.2	Reduce impacts of border-associated structures	2,3	A,E	ongoing	CKWRI, CBP, DHS, USFWS, IBWC, SCT, TxDOT, USDOT	NO	210	30	30	30	30	30	30	30	Variable according to intermittent border projects

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
2	2.2.3	Maintain and enhance thornscrub and other appropriate habitats near the border	2	A,E	ongoing	DHS, USFWS, IBWC, TNC	NO	140	20	20	20	20	20	20	20	Ongoing
1a	2.3	Minimize impacts to ocelots from residential and commercial development, wind farms, and other activities	2,3	A,E	ongoing	USFWS	YES	364	52	52	52	52	52	52	52	Ongoing; predicted consultation costs
1b	3.1.1	Monitor genetic health and diversity in Texas populations; evaluate genetic augmentation	2	A,E	7	CKWRI, DZ, USFWS, UA	YES	42	6	6	6	6	6	6	6	For analysis of 40 samples per year
1b	3.1.2	Monitor genetic health and diversity in Tamaulipas populations; evaluate genetic augmentation	2	A,E	7	CKWRI, USFWS, SEM, UNAM	YES	42	6	6	6	6	6	6	6	For analysis of 40 samples per year
3	3.1.3	Characterize genetic status and variability of the Arizona/Sonora ocelots	3	A,E	2	USFWS, SEM, UA	NO	20	12	8						For sample collection (2008), and genetic analysis (2009), of 60 Sonoran ocelot samples
2	3.1.4	Design genetic augmentation program and protocols for core populations	2	A,E	4	CKWRI, DZ, USFWS, UA	NO	115	40	25	25	25				
2	3.1.5	Evaluate artificial reproductive techniques; if appropriate, create gene bank	2,3	A,E	7	AZA, DZ, USFWS	NO	35	5	5	5	5	5	5	5	Dr. Bill Swanson of Cincinnati Zoo has lead on Ocelot Artificial Reproductive Technology (10+ y research)
3	3.1.6	Evaluate establishment of genetic breeding program	2	A,E	1	AZA, CKWRI, USFWS	NO	10	10							3 day meeting in 2008 to evaluate the efficacy

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
3	3.2.1	Conduct experimental translocations	2	A,E	2	CKWRI, USFWS, SEM, TPWD	YES	1500	500	500	500					
3	3.2.2	Augment existing populations as necessary through translocation	2	A,E	2	CKWRI, USFWS, SEM, TPWD	NO	2000				500	500	500	500	Ongoing as necessary
3	3.2.3	Evaluate feasibility of using confiscated ocelots to augment populations	2	A,E	1	DZ, USFWS, GPZ	NO	5	5							
2	3.3	Identify an area in Texas for establishing a new ocelot population	2	A,E		USFWS, PL, TPWD	YES	40		10	30					
3	3.4	If appropriate, establish a new population in Texas	2	A,E		USFWS	YES	850				150	200	250	250	Rule development, NEPA, permits, implementation
2	3.5.1	Establish protocols for physiological assessment and individual identification	2,3	C,E	1	CKWRI, USFWS, SEM, UNAM	NO	2	2							
3	3.5.2	Conduct serology and pathology surveys	2,3	C,E	7	CKWRI, USFWS, SEM, UNAM	NO	70	10	10	10	10	10	10	10	
3	3.5.3	Create a tissue bank for ocelot samples	2,3	C,E	7	CKWRI, USFWS, SEM, UNAM	NO	7	1	1	1	1	1	1	1	Cost to maintain freezers
2	3.5.4	Establish protocols for treatment of injury, diseases, parasites	2,3	C,E	1	AZA, UNAM	NO	2	2							
3	3.5.5	Establish database of medical and genetic ocelot data	1,2,3	C,E	7	AZA, CKWRI, USFWS, UNAM	NO	10	4	1	1	1	1	1	1	Create database (2008), maintain database (2009-2014)
3	3.5.6	Investigate measures to prevent disease	1,2,3	C	4	AZA, CKWRI, USFWS, UNAM	NO	5	2	1	1	1				

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s) 2010	2011	2012	2013	2014	2015	2016	Comments
3	3.6.1	Research contamination in ocelots and prey; provide solutions to toxicity problems	2,3	C,E	3	CKWRI, USFWS, UNAM	NO	95	35	35	25					
3	3.7.1	Conduct field studies of niche overlap between ocelot and competitors	1,2,3	E	4	ADGF, CKWRI, USFWS, UNAM	NO	205	60	50	50	45				
2	4.1.1	Develop regional recovery working groups for ocelot conservation	2,3	A,B,C, D,E	3	USFWS, SEM, TPWD	YES	30	10	10	10					
2	4.1.2	Continue recovery through Implementation and Technical Subgroups of Recovery Team	1,2,3	A,B,C, D,E	ongoing	AGFD, AZA, USFWS, PL, TPWD	YES	35	5	5	5	5	5	5	5	
1b	4.1.3	Develop cooperative conservation projects with willing landowners	2	A,B,D, E	ongoing	AGFD, DOW, ED, USFWS, SEM, TPWD	YES	35	5	5	5	5	5	5	5	
1b	4.1.4	Develop and implement incentive programs for landowners to implement recovery on non-federal lands	2	A,B,D, E	ongoing	AGFD, ED, USFWS, SEM, TPWD	YES	115	5	15	15	20	20	20	20	
2	4.1.5	Support work by biologists in Mexico to survey habitat	1,2,3	A		AGFD, DOW, USFWS, PRNA, SEM, TPWD	NO	100	50	50						
2	4.1.6	Develop partnerships with Mexican agencies and landowners to implement recovery actions	2,3	A,B,C, D,E	3	DOW, ED, USFWS, NAT, PRNA, SEM, TNC	YES	40	10	10	10	10				
1b	4.1.7	Encourage participation by DHS and CPB with conservation agencies	2,3	A,E	3	USFWS	YES	35	5	5	5	5	5	5	5	

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
1b	4.2.1	Encourage development and enforcement of regulations in Mexico to protect ocelots	1,2,3	D		USFWS, PRNA, SEM	NO	140	20	20	20	20	20	20	20	
2	4.2.2	Assure compliance with regulations for oil and gas development and seismic operations	2,3	A,D	ongoing	USFWS	YES	14	2	2	2	2	2	2	2	
2	4.3.1	Maintain an education/outreach working group	2,3	A,B,E	7+	AGFD, AZA, DOW, ED, USFWS, TPWD	NO	14	2	2	2	2	2	2	2	Others? Sky Island Alliance, Borderlands Working Group, Audubon, Sierra Club
2	4.3.2.1	Develop education materials and plans for Texas and Arizona	2	A,B,E	7	AZA, USFWS, TPWD, AGFD	NO	50	5	10	10	10	5	5	5	
2	4.3.2.2	Develop education materials and plans for Tamaulipas and Sonora	2,3	A,B,D, E	7-Jan	AZA, DOW, PRNA, NAT, SEM	NO	35	5	5	5	5	5	5	5	Other Mexican education groups?
3	4.3.3	Monitor and assess effectiveness of outreach efforts	2,3	A,B,D, E	5	AZA, DOW, PRNA	NO	40			10	5	10	5	10	Start evaluation 2 y after implementation and then every two years
1b	4.3.4	Educate hunters, landowners, and predator control personnel to refrain from killing ocelots	1,2,3	B	7	TPWD	NO	3.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Annual attendance at trapper rendezvous to discuss ocelot
2	5.1	Develop monitoring schedule and protocol for core populations	2	A,B,C, D,E	2	CKWRI, USFWS, SEM	YES	10	5	5						
1b	5.2	Develop agreements to survey populations and habitats on non-federal lands	2	A,B,C, D,E	ongoing	AGFD, CKWRI, ED, USFWS, TPW	NO	35	5	5	5	5	5	5	5	

Priority Number	Action Number	Recovery Action Description	Recovery Criterion Number(s)	Threats	Action Duration (Years)	Responsible Parties	Is USFWS Lead?	Total Cost ($1,000s)	Cost Estimate by Year (by 1,000s)							Comments
									2010	2011	2012	2013	2014	2015	2016	
3	5.3	Conduct monitoring of recovery	1,2,3	A,B,C, D,E	7	AGFD, CKWRI, USFWS, SEM, TPWD	YES	896	128	128	128	128	128	128	128	
3	5.4	Prepare annual report of ocelot monitoring results	1,2,3	A,B,C, D,E	7	CKWRI, USFWS, TPWD	NO	7	1	1	1	1	1	1	1	
2	5.5	Develop data sharing and data repository	1,2,3	C,E	7	AGFD, CKWRI, USFWS, SEM, TPWD	NO	35	5	5	5	5	5	5	5	
2	6.1	Track skin locations to determine source of illegal harvest	1,2,3	A,B,C, D,E	7	CKWRI, USFWS	NO	7	1	1	1	1	1	1	1	
3	6.2.1	Provide support for a routine workshop every 3-5 years to gather ocelot information	1,2,3	A,B,C, D,E	ongoing	DOW, USFWS, NAT, PRNA, SEM	YES	75		25			25		25	
2	6.2.2	Support international groups to implement Meso-american corridor	1	A,B,C, D,E	ongoing	DOW, USFWS, NAT, PRNA, SEM	YES	24	2	2	4	4	4	4	4	
3	6.3	Coordinate recommendations and available genetic data from international zoos	1,2,3	E	3	AZA	NO	6	2	2	2					

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Appendix I – Figures Cited in Text

Figure 1. Distribution of the ocelot in the western hemisphere (Adapted from Sunquist and Sunquist 2002).

Figure 2. The ocelot is a medium-sized, long-tailed spotted cat.

Figure 3. Distribution of ocelot subspecies occurring in northern Mexico and the southwestern U.S.

Figure 4. Distribution of the ocelot in Texas.

Figure 5. South Texas urban areas relative to USFWS refuges.

Figure 6. Human population growth in south Texas by county from 1990 to 2000.

Figure 1

Figure 2

Photo above from: http://www.ckwri.tamuk.edu/feline/ocelot.htm

Figure 3

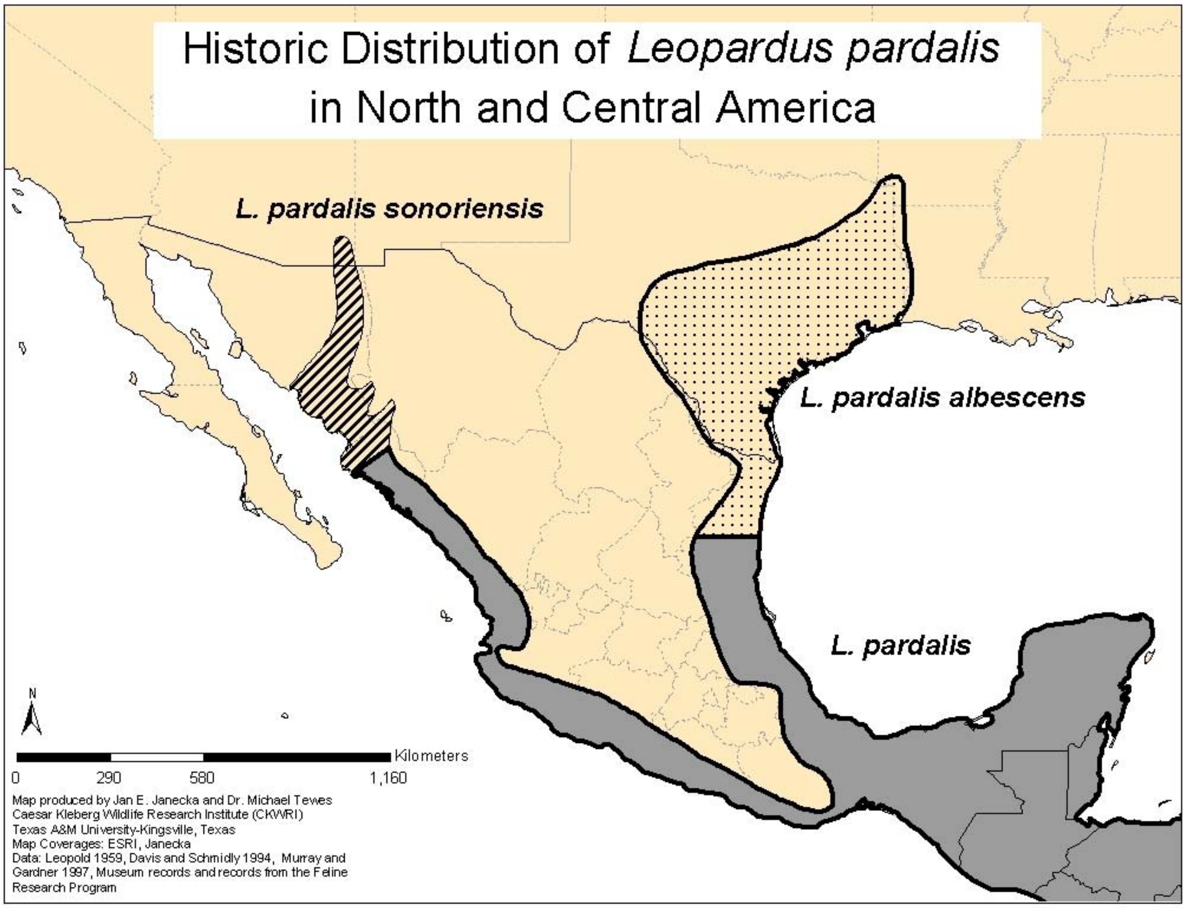
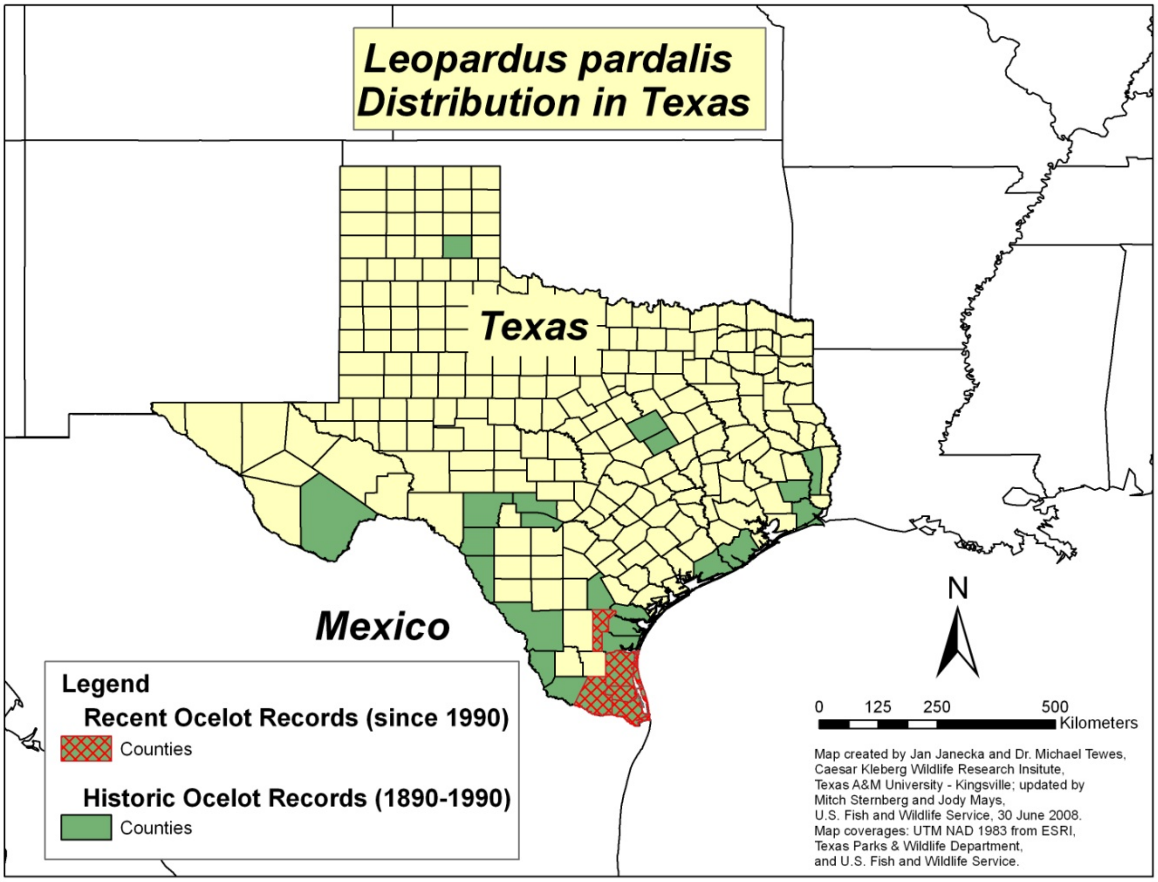

Historic Distribution of *Leopardus pardalis*
in North and Central America
L. pardalis sonoriensis
L. pardalis albescens
L. pardalis
N
Kilometers
0
290
580
1,160
Map produced by Jan E. Janecka and Dr. Michael Tewes
Caesar Kleberg Wildlife Research Institute (CKWRI)
Texas A&M University-Kingsville, Texas
Map Coverages: ESRI, Janecka
Data: Leopold 1959, Davis and Schmidly 1994, Murray and
Gardner 1997, Museum records and records from the Feline
Research Program

Figure 4



Leopardus pardalis
Distribution in Texas
Texas
Mexico
Legend
Recent Ocelot Records (since 1990)
Counties
Historic Ocelot Records (1890-1990)
Counties
N
0 125 250 500
Kilometers
Map created by Jan Janecka and Dr. Michael Tewes,
Caesar Kleberg Wildlife Research Insitute,
Texas A&M University - Kingsville; updated by
Mitch Sternberg and Jody Mays,
U.S. Fish and Wildlife Service, 30 June 2008.
Map coverages: UTM NAD 1983 from ESRI,
Texas Parks & Wildlife Department,
and U.S. Fish and Wildlife Service.

Figure 5

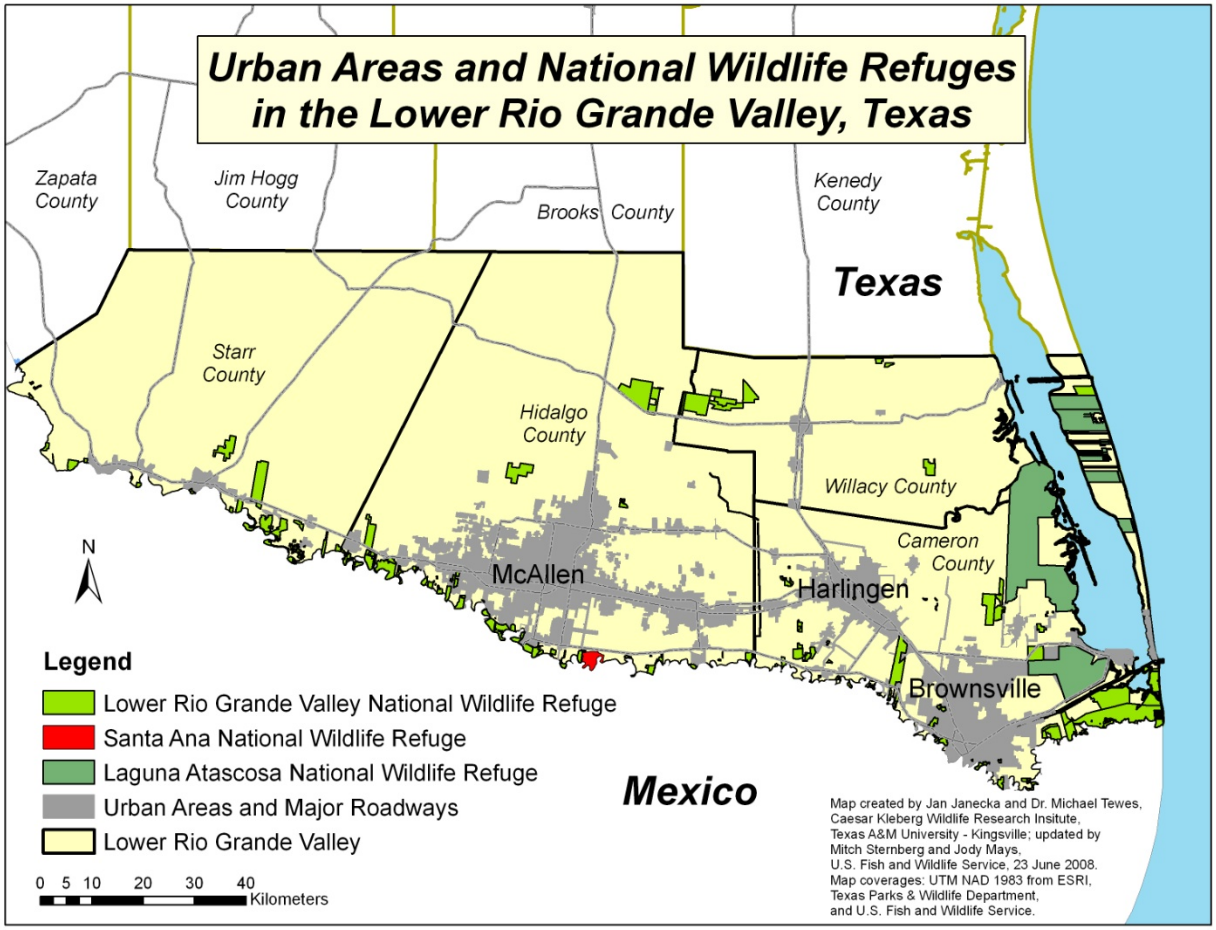
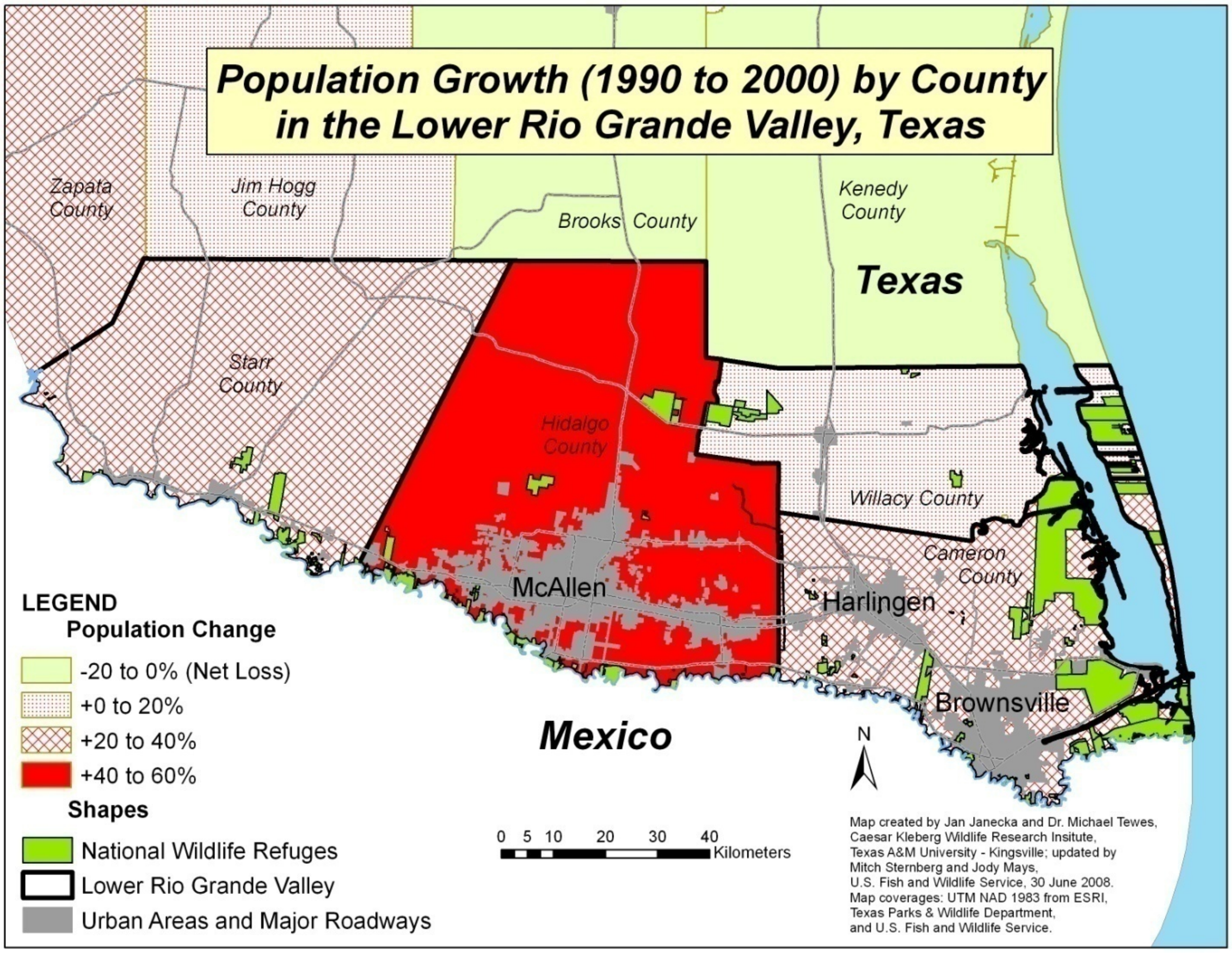

Urban Areas and National Wildlife Refuges in the Lower Rio Grande Valley, Texas
Zapata County
Jim Hogg County
Brooks County
Kenedy County
Texas
Starr County
Hidalgo County
Willacy County
Cameron County
McAllen
Harlingen
Brownsville
Mexico
N
Legend
Lower Rio Grande Valley National Wildlife Refuge
Santa Ana National Wildlife Refuge
Laguna Atascosa National Wildlife Refuge
Urban Areas and Major Roadways
Lower Rio Grande Valley
0 5 10 20 30 40
Kilometers
Map created by Jan Janecka and Dr. Michael Tewes, Caesar Kleberg Wildlife Research Insitute, Texas A&M University - Kingsville; updated by Mitch Sternberg and Jody Mays, U.S. Fish and Wildlife Service, 23 June 2008. Map coverages: UTM NAD 1983 from ESRI, Texas Parks & Wildlife Department, and U.S. Fish and Wildlife Service.

Figure 6


Population Growth (1990 to 2000) by County
in the Lower Rio Grande Valley, Texas
Zapata County
Jim Hogg County
Brooks County
Kenedy County
Texas
Starr County
Hidalgo County
Willacy County
Cameron County
McAllen
Harlingen
Brownsville
Mexico
LEGEND
Population Change
-20 to 0% (Net Loss)
+0 to 20%
+20 to 40%
+40 to 60%
Shapes
National Wildlife Refuges
Lower Rio Grande Valley
Urban Areas and Major Roadways
N
0 5 10 20 30 40
Kilometers
Map created by Jan Janecka and Dr. Michael Tewes,
Caesar Kleberg Wildlife Research Insitute,
Texas A&M University - Kingsville; updated by
Mitch Sternberg and Jody Mays,
U.S. Fish and Wildlife Service, 30 June 2008.
Map coverages: UTM NAD 1983 from ESRI,
Texas Parks & Wildlife Department,
and U.S. Fish and Wildlife Service.

Appendix II – Status of Other Neotropical Felids in the United States

The first recovery plan (USFWS 1990) provided information on the history, distribution and status of jaguarundi (*Herpailurus yaguarondi*), margay (*Leopardus weidii*), and jaguar (*Panthera onca*) in the United States. The USFWS has decided not to address these species in this plan and focus this plan on the ocelot.

Appendix III – Status of the Ocelot Outside of the United States

The ocelot is found in every mainland country south of the U.S. except Chile (CITES 2005). The island countries of Cuba, Dominican Republic, Haiti, Jamaica, and Puerto Rico are not known to have ocelots (CITES 2005), but the island nation of Trinidad and Tobago, located off the Venezuelan coast, supports an ocelot population on Trinidad (Mondolfi 1986). Within the 22 countries supporting the species, 11 ocelot subspecies are described (Pocock 1941, Cabrera 1961, Hall 1981, Eizirik et al. 1998). These 11 described subspecies include: *L. p. aequatorialis* Mearns 1902 (Ecuador), *L. p. ablescens* Pucheran, 1855 (Arkansas, U.S.), *L .p. maripensis* J.A. Allen 1904 (Venezuela), *L. p. mearnsi* J.A. Allen 1904 (Costa Rica), *L. p. mitis* F. Cuvier 1920 (Brazil), *L. p. nelsoni* Goldman 1925 (Mexico), *L. p. pardalis* Linnaeus 1758 (Mexico), *L. p. pseudopardalis* Boitard 1842 (Colombia, Venezuela), *L. p. pusaea* Thomas 1914 (Ecuador), *L. p. sonoriensis* Goldman 1925 (Mexico), and *L. p. steinbachii* Pocock 1941 (Bolivia) (Pocock 1941, Goldman 1943, Cabrera 1961, Eizirik et al. 1998). Five of these occur in North America: *albescens*, *mearnsi*, *nelsoni*, *pardalis*, and *sonoriensis* (Hall 1981). Subspecies reflect geographic races that exhibit differences in size and pelage, with smaller, paler subspecies found farther from the equator and larger, darker races inhabiting areas closer to the equator (USFWS 1990).

Throughout its range, from southern Texas and southern Arizona to northern Argentina and Uruguay, the ocelot is rare and often imperiled. Following the U.S.'s listing of the ocelot as federally-endangered under the Endangered Species Act in 1973, international trade of the ocelot was banned by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1975. The ocelot was listed by CITES in response to dwindling ocelot populations caused by commercial export (McMahan 1986). Originally, the ocelot was categorized as *L. pardalis* under Appendix II in CITES, with two subspecies (*L. p. mearnsi* and *L. p. mitis*, the Brazilian ocelot) listed on Appendix I (CITES 2005). Appendix II species may not be threatened with extinction but need controls on trade to avoid over-utilization (CITES 2005). Appendix II species may be commercially exported as live animals, with required permits, and may be used in products if the exporting country deems that this use is not detrimental to the survival of a species (McMahan 1986). As of 1990, all ocelot subspecies have been listed under Appendix I as a threatened species (CITES 2005).

The World Conservation Union, IUCN Red List, includes the ocelot as a species of "Least Concern" over its entire range (Nowell 2002). Species of Least Concern have estimated population sizes of at least 50,000 (Nowell 2002). Prior to 2002, the ocelot was listed as vulnerable (IUCN 1994). However, the Red List categorizes the Texas subspecies, *L. pardalis albescens*, as endangered due to meeting conditions for criteria D, a population with less than 250 adults (Baillie et al. 2004). The 1996 IUCN Status Survey and Conservation Action Plan for Wildlife Cats ranked the ocelot as: Global 5a; Regional 4. Species holding a G5 rank are considered secure over their entire range (Master 1991). Regional rankings of 4 confer a status of apparent security in a region (100 to 1000 known extant populations), but the species may be rare in parts of its range (Master 1991).

Ocelot population data often are unavailable and vary with changing landscapes and human activities. As of 2002, the ocelot's global effective population size is estimated as 235,000

(Nowell 2002). Effective population size is the portion involved in breeding and, in this case, is obtained using half of the estimated total population (Nowell 2002). Currently, the ocelot is federally-protected through most of its range. Hunting is allowed in Peru, whereas Ecuador, El Salvador, and Guyana offer no legal protection (Fuller et al. 1987). To create a strategy for the ocelot's long-term survival across the Americas, an assessment of ocelot status in each country is needed. Such information may assist international conservation planning and clarify how ocelot research outside the U.S. can be prioritized.

Threats to the ocelot survival are primarily human-caused. Early declines were from over-harvesting when hunting occurred throughout its range. From the late 1800s, international trade focused on the larger cats, such as tiger, cheetah, snow leopard, and jaguar. As large cats became scarce, fur traders shifted to smaller, more abundant species, such as the ocelot. As a result, ocelot pelts were heavily exploited in the 1960s and early 1970s; some ocelots also were imported for the pet trade. During this time, the ocelot was the most sought after spotted cat in the fur industry, mainly for use as furskins, garments, and rugs (McMahan 1986). Up to 200,000 ocelot skins may have been harvested annually for global trade (Geitling 1972 as cited in Payan and Trujillo 2006). Ocelot imports peaked in the U.S. in 1970, with 140,000 skins documented by U.S. Customs (McMahan 1986). With the advent of CITES, ocelot imports dropped to 24,600 skins annually from 1976 and 1983 (Broad 1987). However, international trade in other smaller felids, such as Geoffroy's cat (*F. geoffroyii*), bobcat, jungle cat (*F. chaus*), little spotted cat (*F. tigrina*), lynx (*L. canadensis*), and wildcat (*F. silvertris*) rose, peaking in 1980 with 685,000 total pelts (McMahan 1986). Most international ocelot trade ceased during the late 1980s (Ocelot Fact Sheet Website 2005).

Habitat alteration, particularly from deforestation, agriculture, and cattle ranching, has reduced and fragmented ocelot habitat (Ceballos and Garcia 1995, Lopez Gonzales et al. 2003). Moreover, continued subsistence hunting and poaching of the ocelot are causes of decline or impediments to population recovery (Lopez Gonzales et al. 2003, de Villa Meza et al. 2002, Ceballos & Garcia 1995). Although the ocelot is still widespread in Central and South America, densities are low and populations are often patchy (Dobson and Yu 1993). Ocelot habitats include coastal mangroves, marshes, grasslands, thornscrub, dry semideciduous forests, riverine forests, subtropical forests, and tropical forests.

OCELOT STATUS SOUTH OF THE UNITED STATES

MEXICO

The ocelot is listed as "Endangered" in Mexico by the Mexican Ministry of Environment, Natural Resources, and Ecology (SEMARNAP). Most ocelot habitat occurs on private property and protected areas of Mexico (Caso 1994).

Among 31 states and 1 Federal district in Mexico, 10 states are known to have had ocelot populations within the past 15 years. These states (Campeche, Chiapas, Durango, Jalisco, Queretaro, Sinaloa, Sonora, Tabasco, Tamaulipas, and Veracruz) include the Sierra Madre Occidental range in western Mexico, and the Sierra Madre Oriental in eastern Mexico. Although these states comprise portions of the historic range of the ocelot, its status in Chihuahua, Coahuila, Colima, Guerrero, Michoacan, Niyarit, Nuevo Leon, and San Luis Potosi is poorly known (USFWS 1990, http://fwie.fw.vt.edu/WWW/esis/lists/e052005.htm).

Data for ocelot populations in Mexico are patchy. For instance, anecdotes from 1905 reported the ocelot in coastal dunes in Nayarit (de Villa Meza et al. 2002, citing Allen 1906); however, no recent studies have been conducted here. Ocelots in Colima, Guerrero, and Oaxaca are last known from museum specimens (Goldman 1943), although the lack of credible ocelot sightings in these states does not rule out the ocelot's presence there today. An ocelot skin from the north-central State of Durango in 1994 (Servin et al. 2003) marked the first physical proof of the ocelot for this state, although unsubstantiated reports of ocelots derive from the lower tropical deciduous forests of Durango (Webb and Baker 1962). A single ocelot skin from 1940 (Jimenez and Zuniga-Ramos 1992) and another from 1946 (Jimenez Guzman et al. 1999) was documented in Neuvo Leon. Recent surveys for jaguarundi in Nuevo Leon did not reveal ocelots (A. Caso, pers. comm. 2006).

Within the 10 states where ocelots recently have been found, ocelots appear to use a variety of habitats including subtropical and tropical thornscrub, neotropical dry forest, tropical rain forest, tropical riparian and coastal forest, grasslands, and swamps. Most surveys of ocelots have been limited to noting presence or absence in biosphere reserves. In addition to the loss of habitat from development, impacts along the U.S. border include highways, international bridges, night lighting with effects on nocturnal prey and ocelot movement (Grigione and Mrykalo 2004), increased noise and pollution, and increased exposure to diseases (Grigione et al. 2009).

Campeche: The State of Campeche contains the Calakmul Biosphere Reserve. It became the largest tropical protected area in Mexico (2792.2 mi^2 or 7231.9 km^2) in 1989 (Escamilla et al. 2000), and supports the ocelot (http://www.nature.org/wherewework/fieldguide/projectprofiles/cbr.html, http://parksinperil.org/files/page_2_calakmul_biosphere_reserve.pdf, http://www.parkswatch.org/parkprofile.php?l=eng&country=mex&park=ckbr&page=sum). Inaccessibility, low soil fertility, and lack of surface water have kept this region relatively unoccupied by humans. However, the region is occupied by indigenous people, and is experiencing 9.3% annual population growth (Escamilla et al. 2000). Logging, subsistence agriculture, hunting, and other non-timber forest uses (such as chicle tapping and apiculture) (Escamilla et al. 2000) in southwestern Campeche are causing declines in tropical moist forest, croplands, and wetlands, and increases in grasslands (Cuaron 2000). Hunting combined with habitat loss are the main threats to the ocelot and other wildlife in this region.

Chiapas: Chiapas contains the largest portion of tropical rain forest remaining in Mexico and the highest mammal species richness in the country (Medellin 1994). Reserva Integral de la Biosfera Montes Azules holds the most diverse ecosystem in Mexico with many endemic and migrant species (Medellin 1994). Much of Chiapas and neighboring Oaxaca has been highlighted as an area in Mexico worthy of the highest priority for conservation due to the concentration of endangered species, endemic species, and species richness (Ceballos et al. 1998). Chiapas contains protected areas such as the tropical rain forests of Lacandona and the dry forests of La Sepultura (Ceballos et al. 1998), but tropical forest is being converted to subsistence agriculture and cattle pasture (Cuaron 2000).

Cuaron (2000) found the ocelot in tropical moist forest, cloud forest, wetland, and tropical secondary vegetation in Parque Nacional Palenque (4,447 ac or 1,801 ha) and Montes Azules (287,800 ac or 116,559 ha). Habitat availability for the ocelot declined 18% from 1974 to 2000 in Chiapas, with 24% declines projected by 2034 (Cuaron 2000). Cuaron (2000) determined that ocelots would use fallow croplands and agricultural areas, particularly if they were associated with natural vegetation. No population data for the ocelot in Chiapas were available.

Durango: The ocelot was not found in Durango by Baker and Greer (1962), but residents assured them that it "occurred in the vicinity in the Tropical Deciduous habitat" (Webb and Baker 1962). In 1994, an ocelot skin was obtained from hunters who captured it along a river in deciduous tropical forest along the western slope of the Western Sierra Madre, providing the first official record of the species in Durango (Servin et al. 2003). No other ocelot data were available.

Jalisco: Threats to tropical dry forest in Jalisco include burning and clearing for agriculture and grazing, selective logging, and resort development (particularly along the coast), which causes isolation of remnant native vegetation. Construction of resort hotels, real-estate developments, polo fields, and marinas has destroyed wetlands in this region of poor soils and little surface water (Lott 1995). Jalisco includes Pacific coastal beaches, mangroves, and marshes merging into the Sierra Madre Occidental. "Jalisco dry forests," paralleling the Pacific coast of Mexico (Valero et al. 2001), maintain high species richness and endemism (Ceballos and Garcia 1995).

The Chamela-Cuixmala Biosphere Reserve (13,600 ha or 33,580ac) comprises the only protected area in the Jalisco dry forest ecoregion, which includes the adjacent States of Nayarit and Colima (Ceballos et al. 1998). The Reserve protects less than 10% of the ecoregion (Valero et al. 2001). Fernandez (2002) monitored 15 radio-collared ocelots between 2000 and 2001 and estimated that the Reserve could support 33 to 53 adult ocelots (0.3 ocelots/km^2). A viable ocelot population may exist in the reserve (Ceballos and Garcia 1995).

Indirect threats to the ocelot in Chamela-Cuixmala Biosphere Reserve may include competition from subsistence hunters for prey (considered a delicacy) (de Villa Meza et al. 2002). The spiny-tailed iguana (*Ctenosaura pectinata*) was the most important prey of ocelots in this area, followed by the spiny pocket mouse (*Liomys pictus*) (de Villa Meza et al. 2002). Fewer iguanas may reduce ocelot kitten survival by forcing females to spend more time foraging for smaller prey (de Villa Meza et al. 2002).

Queretaro: The ocelot was documented in the 3000 km^2 (1155 mi^2) Reserva de la Biosfera Sierra Gorda (Lopez Gonzales, pers. comm. 2006), but population data are not known. The Reserve, located in central Mexico, covers 14 different habitat types, from semi-desert scrub to tropical cloud forests. Tropical deciduous gallery forests dominate the region, with some areas of coniferous and tropical oak forests. The diversity of flora and fauna is a result of the topographic extremes and the interplay of Nearctic and Neotropic regions (http://www.woodrising.com/icwb/sgdescription.pdf)

Sinaloa: Threats to native landscapes including coastal plain, mangrove, marsh, semi-arid brushland, and montane woodland (Armstrong et al. 1972) in Sinaloa include wetland pollution, intensive agriculture, and shrimp farming along the coast (http://www.ducks.org/conservation/icp/Part2/WestCoastMexico.html). Inland areas with steeper terrain are well-preserved (Lopez Gonzales, pers. comm. 2005). The ocelot was apparently common in southern Sinaloa until the 1950s (Burt 1938, Leopold 1959). The ocelot (*F.p. nelsoni* Goldman 1925) may occur in forested areas throughout Sinaloa but population estimates are unavailable (http://www.ducks.org/conservation/icp/Part2/WestCoastMexico.html, http://www.tourbymexico.com/sinaloa/escuina/escuina.htm, http://www.vallarta-adventures.com/jeep-safari/ecology.html).

Sonora: Sonora supports 0.15 ocelots per mi^2 ($0.057/km^2$) and an estimated state-wide population of 2025 ± 675 (Lopez-Gonzales et al. 2003). These numbers were estimated from interviews, tracks, artifacts, and a predictive model. Thirty three ocelots have been documented in Sonora since 1998, the most of any northern Mexican state (Lopez-Gonzales et al. 2003). The core habitat necessary to support ocelot populations in the region was calculated to be 12,175.7 mi^2 (31,535 km^2), with 1.9% of this area minimally protected (defined by the IUCN as class VI protection - managed for sustainable resource use, but with no protection from road construction, poaching, or habitat alteration) (Lopez-Gonzales et al. 2003). As the second largest state in Mexico and with one of the lowest human population densities, Sonora offers a large area of contiguous habitat (Lopez-Gonzales et al. 2003), including thornscrub and other semi-arid vegetation (Caso 1994).

Tabasco: Cuaron (2000) predicted an increase in grasslands and decrease in tropical moist forests, croplands, and wetlands in the panhandle of Tabasco. The expected decrease in vegetative cover and accompanying fragmentation of remaining forest may have a negative effect on the local abundance and metapopulation dynamics of the ocelot in the panhandle region. Ocelots are known to occur in this area, based on local accounts, but numbers of individuals are unknown (http://www.birdlist.org/nam/mexico/tabasco/tabasco.htm, http://www.parkswatch.org/parkprofile.php?l=eng&country=mex&park=ltpa&page=bio, http://www.parkswatch.org/parkprofiles/pdf/pcbr_eng.pdf).

Tamaulipas: Ocelot habitat ranges from desert scrub (Tamaulipas mesquital or matorral), coastal gulf grasslands, and lowland tropical moist forest (Wagner et al. undated, World Wildlife Fund Global Ecoregions Website 2001). Caso (unpublished) photographed 2 ocelots in northern Tamaulipas (located approximately 109 mi [175 km] south of Texas). A total of 36 ocelots from Los Ebanos Ranch in eastern Tamaulipas (located approximately 168 mi [270 km] south of Texas; Caso 1994) and 10 ocelots in central Tamaulipas (A. Caso unpublished data). The ocelot was historical reported at Nuevo Leon; however, recent surveys didn't find any evidence of ocelots in the state (A. Caso unpublished data). Probably, the most important area with ocelot habitat in northeast Mexico is located at Sierra of Tamaulipas where Caso captured 10 ocelots in 1996.

Veracruz: Veracruz is the type locality for the ocelot described, as *Felis pardalis*, by Linneas in 1758 (Hall 1981). Recent ocelot population data for Veracruz is not published, however, 2 ocelots were captured 30 miles south of Tampico, at La Mesa Ranch, Veracruz in 1994 (A. Caso, pers. comm. 2006) and the ocelot has been reported at the Los Tuxtlas biological station in southern Veracruz (http://www.parkswatch.org/parkprofile.php?l=eng&country=mex&park=ltbr&page=bio). Los Tuxtlas is a 700 ha biosphere reserve within a patchwork of reserve areas consisting of neotropical moist forest and pine-oak forest on volcanic soils, totaling 599 mi^2 or 155,122 ha.

CENTRAL AMERICA

The 7 countries here support an estimated 24,000 species of vascular plants (5000 endemics), 521 mammals (210 endemics), 1193 birds (251 endemics), hundreds of indigenous human tribes, and 25% of all classified unique life zones on Earth (CI 2004a). Less than half of the region retains its original forest cover, and an estimated 45 ha of forest are lost every hour (4000 km^2/yr) (CI 2004). Nearly half of the people live in rural areas. Population growth and poverty place increased pressure on natural resources. The penalties for illegal resource extraction are often negligible compared to the profits. Poverty, ineffective law enforcement, and the lack of incentives that support conservation, are root causes of poaching, logging, and human encroachment that may threaten the ocelot (CI 2001).

Central American governments have taken some steps to protect biodiversity. All nations are signatories of the Convention of Biological Diversity, a United Nations 1992 initiative which promotes the conservation of biodiversity at the genetic, species, and ecosystem levels and the sustainable use of its components, and supporters of Agenda 21, a 1992 United Nations global partnership fostering sustainable development and human empowerment. In addition, they all participate in the Central American Protected Areas System and the Mesoamerican Biological Corridor, a plan to maintain connectivity between protected areas (CI 2001). Currently, protected areas cover approximately 18% of Central America, ranging from less than 3% in El Salvador to 45% in Belize (CI 2001).

BELIZE

The ocelot is listed as CITES I endangered in Belize which has the highest density of felines in Central America including all five CITES I species (jaguar, puma, ocelot, margay, and jaguarundi) (Carrillo and Vaughan 1994). Approximately 47% of Belize is under some form of protected status, forming large, contiguous blocks of forest that abut Mexico and Guatemala (Wildlife Conservation Society 2005). Belize has a relatively small human population, and less deforestation and illegal wildlife hunting than elsewhere in the region (Wildlife Conservation Society 2005). Ecoregions include subtropical and tropical forest, tropical and subtropical coniferous forest, and coastal mangroves in a country that covers 1,081 mi^2 (2,800 km^2). Hurricanes and timber harvest provide irregular disturbances (Konecny 1989). Land clearing for ranching, agriculture, and shrimp farming have fragmented ocelot habitat (Wildlife Conservation Society 2005).

Two radio-collared ocelots used second growth forest, but preferred late successional forest (Konecny 1989). Home ranges, habitat associations, and diet were related to prey density, conspecifics, and competitors (Konecny 1989). The low number of ocelots trapped in this two year study was attributed to illegal hunting (Konecny 1989).

In northwest Belize, ocelots have used fallow fields as well as tropical forests (Miller, pers. comm. 2006). During a 60-day jaguar study in 2004, 18 ocelots were photographed, yielding a relative abundance of 30 ocelots/100 trap nights (Miller, pers. comm. 2006).

Dillon (2005) estimated ocelot density in western Belize at 0.490-0.536 ocelots/mi^2 (0.189-0.207/km^2) in tropical rain forest and 0.060-0.098 ocelots/mi^2 0.023-0.038/km^2) in adjacent pine forest. Home ranges of 8,148 ac (3,300 ha) and 5,210 ac (2,110 ha) were estimated for males and females, respectively, with more overlap between and within sexes than in other ocelot studies (Dillon 2005). Daily distance traveled were 1.6 mi (2.6 km) for males and 1.1 mi (1.8 km) for females (Dillon 2005). Ocelots were active mainly at night, with peaks at sunset and midnight (Dillon 2005).

COSTA RICA

The ocelot is classified as endangered (Carrillo et al. 2000), 24% (4,747 mi^2 or 12,295 km^2) in Costa Rica and this country contains the most privately-owned protected areas in Central America (CI 2001). Since the 1990s, tourism has been Costa Rica's primary source of income, but some of the tourism industry has developed at a pace that disregards local ecosystems (CI 2001). Banana and coffee plantations are used by ocelots if located near large natural forests (Daily et al. 2003). Subsistence hunting, mining, forest extraction, and human encroachment impact primary forests (Carrillo et al. 2000). A proposed "Trans-Talamanca" highway threatens natural areas in Costa Rica by crossing Amistad International Park and other protected areas and indigenous territories (CI 2001). In addition, management plans for protected areas in Costa Rica are "nonexistent, outdated, or inefficient," complicating conservation efforts (CI 2001).

The ocelot inhabits tropical rainforests in three protected areas: La Selva Biological Station (Wilson 1989, Medellin 1994), Corcovado National Park (161 mi^2 or 418km^2), and Golfo Dulce Forest Reserve (242 mi^2 or 627km^2) (Carrillo et al. 2000). Typically, conservation laws are better enforced in national parks than in forest reserves (Carrillo et al. 2000). The latter two areas are located on the Oso Peninsula in the Pacific Ocean. Based on transects in 1990, 1992, and 1994, Carrillo et al. (2000) reported 0.19 ocelot tracks/mi (0.12 ocelot tracks/km) in Corcovado National Park and 0.21 tracks/mi (0.08 tracks/km) in Golfo Dulce Forest Reserve. Although humans do not hunt ocelots on the Oso Peninsula, they do hunt ocelot prey (Carrillo et al. 2000). The increase in human population, changes in hunting methods, and the sedentary habits of people intensively using a limited area are other factors responsible for increased effects of subsistence and commerce hunting on native wildlife (Carrillo et al. 2000).

Ocelots used tropical forest and adjacent coffee and banana plantations at Las Cruces Biological Field Station (Daily et al. 2003). The ocelot was categorized as a 'moderately sensitive' species, using a wide range of forest habitats (Daily et al. 2003). Mature coffee plantations near forest remnants may enhance the conservation value of fragmented forests (Daily et al. 2003).

The ocelot has been documented intermittently at La Selva Biological Station since 1968 (Wilson 1989, www.ots.ac.cr/en/laselva/). La Selva consists of 3,736 ac (1,513 ha) and is contiguous with Braulio Carrillo National Park. Together they cover 120,988 ac (49,000 ha). This area is near the center of the ocelot's range in the Western Hemisphere (Wilson 1989). At

La Selva, the most recent sighting of an ocelot by a biologist occurred in 1998 (http://www.ots.ac.cr/en/library/liana/fall98/sightings.htm).

EL SALVADOR

The ocelot is unprotected in El Salvador, one of three countries that allows it to be hunted (Ocelot Fact Sheet Website 2005). The ocelot has not been studied in El Salvador. It is the smallest country in the Americas, but it supports approximately 7 million people with a density of 838 humans/mi^2 (324/km^2) (Woodward 2005). Natural vegetation is dominated by deciduous tropical forest, with areas of temperate grasslands and sparse forests of oak and pine. As a result of its high population density and farming, only 6% of El Salvador remains forested (Woodward 2005), with 2% considered primary forest (Scialabba and Williamson 2004). Subjected to one of the highest annual rates of deforestation in the world, shrinking areas of forest have led to the extirpation of several carnivorous species. Less than 1% of the country is protected (Woodward 2005).

El Salvador's primary export is coffee, 25% of which is "shade-grown" under a canopy of both cultivated and native trees that often grow adjacent to native forests (Scialabba and Williamson 2004). Shaded coffee polycultures are floristically and structurally complex, have relatively high species diversity, and are used by ocelots (Scialabba and Williamson 2004). In 1998, a World Bank Global Environment Facility project was initiated to link the protected areas of El Imposible and Los Volcanes by supporting biodiversity conservation within the coffee plantations forming the corridor (Scialabba and Williamson 2004).

GUATEMALA

The ocelot is protected in Guatemala and occurs in the northeast Peten section of the country (Lickey et al. 2005). Guatemala is dominated by tropical moist forest (~70%), with 26.3% protected (CI 2004). Today, the Peten and its surrounding forests represent the largest remaining expanse of tropical forest in Central America (Lickey et al. 2005) and include: El Mirador National Park, Biotope Dos Laguna, Rio Azul National Park; Biotop El Zotz, Tikal National Park, and the Reserva de la Biosfera Maya (Novack 2003). Human encroachment into parks and protected areas (i.e., Laguna del Tigre National Park and Sierra del Lacandon National Park), in addition to proposed highway projects (Mirador Rio Azul National Park) and proposed dam construction (Sierra del Lacandon National Park), threaten ocelot habitat (Soto Shoender, pers. comm. 2006). In addition to logging, road building, illegal poaching, land conversion for agriculture and rangelands, Guatemala also has a high incidence of forest fires. Periodic drought and creation of rangelands have resulted in fires covering large areas (CI 2004).

In Mirador Rio Azul National Park, 5.7 ocelots/100 trap nights were documented (Soto Shoender, pers. comm. 2006). Novack (2003) photographed 9 ocelots at 32 locations, producing 1.1 ocelot captures/100 trap nights (Novack 2003). He also had 1.3 ocelots/100 trap nights in Rio Azul/Dos Lagunas National Park (Novack 2003). Eight years earlier, 1.05 ocelots/100 trap nights were photographed in Tikal National Park (Kaewanishi 1995). To the south, 1.4 ocelot captures/100 nights and 0.83 track detections/km were recorded in the 14,000 ha (54 mi^2) Lachua

Lagoon National Park, an area surrounded by human communities (Soto Shoender, pers. comm. 2006).

Land cover patterns may remain stable through 2034 (Cuaron 2000). Previously, change in land area altered by agriculture from 1980 to 1999 involved 76.7 million ha (CI 2004). Little is known of the ocelot's status in Guatemala, but given the stability and the existence of available habitat, threats to the ocelot in this region appear to be minimal.

HONDURAS

Although Goldman (1943) and CITES (2005) list the ocelot in Honduras, it has not been formally documented there. Hunting of ocelots is not permitted (Ocelot Fact Sheet Website 2005).
Tropical forests cover almost 50% of Honduras, although these are dwindling due to deforestation from logging, agriculture, and ranching. In 2005, the human population was nearly 7 million, with an average population density of 161 people/mi^2 (62 /km^2; Encarta 2005). National parks, reserves, and refuges account for 20.8% of the country, with the Río Plátano Biosphere Reserve covering about 2,027 mi^2 (5,250 km^2) in north-eastern Honduras. This reserve extends from the mangroves (Miskito Coast), through lowland pine savanna, and into the mountains (Herrera-MacBryde 1993). This area, combined with the Nicaragua's adjacent Bosawas Reserve, was the largest tract of lowland primary tropical rain forest combined with intact pine forests in Central America (Herrera-MacBryde 1993). Enforcement of international agreements to conserve biodiversity is hampered by inaccessibility (Encarta 2005). Deforestation by migratory farmers and loggers in the Rio Plátano Biosphere Reserve is estimated to be 210 mi^2/yr (645 km^2/yr) mainly in lowland hardwoods (Herrera-MacBryde 1993).

NICARAGUA

The ocelot occurred in Nicaragua more than 60 years ago (Goldman 1943), but no scientific documentation has occurred since then. Protected areas in Nicaragua include 5 parks, reserves, or refuges, and cover 2,783.6 mi^2 (7,209.6 km^2) (CI 2001). Nicaragua's largest forest reserve is the Bosawas, (located just south of Honduras' Rio Plátano Biosphere Reserve), which encompasses several indigenous groups and several distinct ecoregions, such as coastal grassbeds, mangrove lagoons, and tropical forest. Nicaragua also has 68 other protected areas, totaling 8,451 mi^2 (21,888 km^2), many of which border the Atlantic Ocean and may serve as corridors between larger, protected areas (CI 2001). Many reserves are vulnerable to deforestation and subsistence hunting because they contain rural indigenous communities (CI 2001). From 1990-1995, Nicaragua had annual deforestation rates of 2.3-2.5% (CI 2001). Much of this habitat alteration was driven by the demand for increased pastures and plantations (CI 2001).

Ocelots inhabit Nicaragua and many show up at street markets as part of the illegal pet trade selling for \$10-\$150 (Hendrix 2000). Female ocelots are killed to obtain their kittens to supply the pet demand (Oldfield 1988). Enforcement of environmental laws is weak, but the Ministry of Environment and Natural Resources is beginning to study the pet trade trends and aims to change Nicaragua's role as a major source for the illegal wildlife trade (Hendrix 2000).

PANAMA

Much of the wildlife research in Panama has taken place on Barro Colorado Island (BCI), a 3,750 ac (1,500 ha) island preserve that was formed by the creation of the Panama Canal. The island has never been inhabited by humans and has been completely protected since 1940 (Glanz 1990). Jaguar and puma rarely exist on the island, leaving the ocelot as one of the top predators here (Asquith et al. 1997). The Smithsonian Tropical Research Institute (STRI) is located on BCI where 11 radio-collared ocelots are part of an eco-physiological study of the species. In 2003, a male ocelot was captured that weighed 18.4 kg, the largest recorded in the wild (STRI 2004). A pilot study, presented in 2002, found that ocelots captured in wooden live traps were calmer and less likely to injure themselves than ocelots captured in metal live traps.

Asquith et al. (1997) found that fewer seeds were consumed by small mammals on larger islands and the mainland sites compared to smaller islands. This was attributed to more species and abundance of predatory mammals in larger areas that prey on seed predators. Ocelots are present on BCI and the mainland, but not on islands smaller than BCI (Asquith et al. 1997).

Panama has protected 1,563 mi^2 (4,049 km^2) in the SICAP (Central American System on Protected Areas) (CI 2001). Deforestation may be the biggest threat to the ocelot in Panama, occurring at 2.3-2.5%/yr from 1990-1995 and in preserved lands despite environmental protection laws (CI 2001). Designated parks are too understaffed to provide needed enforcement, with 149 guards assigned to 14 national parks (22,813 ac/guard or 9,125 ha/guard) (CI 2001). Recently approved large-scale mining projects, land conversion and subsequent erosion due to cattle grazing, illegal hunting, conflicting claims of land ownership, and population growth are challenges to biodiversity conservation in the region (CI 2001).

An agreement supported by Panama's National Environmental Authority (ANAM) and the Wildlife Conservation Society (Franco 2003) will initiate the first long-term study of native cats in Central America and will cover the 2,201 mi^2 (57,000 km^2) Darien Park which borders Colombia and the 200,000 ha Friendship Park of Panama and Costa Rica (Franco 2003). Goals of this agreement are to promote better management of biological corridors, and to reduce deforestation (particularly of remaining primary forest) and shooting of cats (especially jaguars) by ranchers (Franco 2003).

<u>SOUTH AMERICA</u>

ARGENTINA

The ocelot inhabits the northern half of Argentina, including the central Gran Chaco area and vicinity (Redford and Eisenberg 1989), the Upper Parana Atlantic Forest (Di Bitetti et al. *in press*) and the Tropical Andes Forest (Lucherini et al. 2004). The primary threat to the ocelot in Argentina is habitat loss (Di Bitetti et al. 2006). Areas in both the Atlantic Tropical Forest and the Tropical Andes Forest contain at least five other cat species (Lucherini et al. 2004). In terms of habitat selectivity, the ocelot is considered the most specialized (Lucherini et al. 2004).

Yanosky (1994) documented the ocelot on the El Bagual Ecological Reserve in northeastern Argentina. Di Bitetti et al. (2006) used cameras in two study areas in the Atlantic Forest within the northeastern panhandle, bordering Paraguay to the west and Brazil to the east. One study area encompassed mature forest in most of Urugua-i Provincial Park, Urugua-i Private Reserve, and a mixed pine plantation owned by a timber company. The second study site was situated within southern Iguazu National Park, established in 1934, that has an intact native species assemblage and is strictly protected. A population density of 0.33 ocelots/mi^2 (0.129/km^2) was estimated for the Urugua-i site of 59.8 mi^2 (155 km^2), and the Iguazu site of 107 mi^2 (278 km^2) contained an estimated 0.49 ocelots/mi^2 (0.19/km^2) (Di Bitetti et al. 2006). In 1995, Crawshaw used radio telemetry to estimate an ocelot population density of 0.36/mi^2 (0.14/km^2) in a northern portion of Iguazu National Park.

BOLIVIA

The ocelot occurs in Bolivia and is a resident of the newly created Kaa-Iya del Gran Chaco National Park (13,282 mi^2 or 34,400 km^2) (Taber et al. 1997). As the largest, protected dry forest in the world (Wildlife Conservation Society 2004), this park protects 22% of the Bolivian Chaco and 4.7% of the Gran Chaco ecoregion of south-central South America (Taber et al. 1997). The main threats concern human encroachment and the conversion of forest and riparian areas into soybean monoculture (Taber et al. 1997). Another threat is the development of the Santa Cruz-Sao Paulo gas pipeline, one of South America’s most extensive construction projects (Taber et al. 1997). The pipeline is expected to cross the remote northern one-third of the park, an area that was previously inaccessible (Taber et al. 1997).

Population densities of ocelots were assessed using camera trapping models at five Bolivian dry forest sites occurring within the Kaa-Iya del Gran Chaco National Park in the northern end of the Gran Chaco region (Maffei et al. 2005). Results ranged from zero ocelots at a site consisting of chaco woodland on sand dunes in alluvial plains to 1.55 ocelots/mi^2 (0.6 ocelots/km^2) for the largest study area, characterized by transitional and mature chaco forest on sandstone (Maffei et al. 2005). The total ocelot population in Kaa-Iya National Park likely exceeds 10,000 adults (range 9300-11,300), based on an average ocelot density of 0.77 individuals/mi^2 (0.30 individuals/km^2) (Maffei et al. 2005).

BRAZIL

Because of its large size, Brazil likely has the most ocelots (*L. p. mitis*) of any country, but nation-wide population estimates were not found. Brazil contains several ecoregions, including the Amazonian rainforest, the Pantanal (the world’s largest continuously flooded region), the Cerrado (the world’s most biologically diverse savanna/dry forest occupying 20% of the country; TNC 2005 website: http://nature.org/wherewework/southamerica/brazil/work/art5082.html); and the fragmented Atlantic coastal forest, of which only 8% remains (WWW website: http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0176_full.html. 9/23/2005, Leite et al. 1999, Cullen et al. 2005). Commercial export of all wildlife was outlawed in 1967, but enforcement of these laws occurred later (McMahan 1986).

In 1984, Emmons failed to document Brazilian ocelots in a study conducted at seven tropical forest sites. She speculated that the species was still recovering from former hunting pressures (Emmons 1984).

Home ranges of 3 ocelots on a 1,825 ac (730 ha) private ranch in the Pantanal ranged from 190 to 393 ac (76 to 157 ha) (Crawshaw and Quigley 1989). Habitat use was in proportion to availability and home ranges of the two adults did not overlap (Crawshaw and Quigley 1989). Using cameras and modeling, Trolle and Kery (2003) estimated 9-14 ocelots in a 4,428 ac (1771 ha) of Pantanal consisting of open and closed canopy forest in a research and conservation reserve area. In this reserve, ocelot density was estimated to be 1.3-2.1 ocelots/mi^2 (0.51-0.79/km^2. Viana et al. (2005) estimated that the ocelot was 3 times more abundant than other felid species in the Parque Estadual do Rio Doce (139 mi^2 or 360 km^2) rainforest in the State of Minas Gerais.

Project Wild Cats of Brazil was initiated in 2004 to examine the status and management needs of 15 cat species in Brazil (Oliveira 2005). It uses cameras, radio telemetry, and scat analysis to provide data on species community composition within habitats, abundance, home range movements, genetic status, and the viability of captive zoo-bred cats for re-introduction (Oliveira 2005- http://lynx.uio.no/lynx/catsgportal/project-o-month/02_webarchive/grafics/july2005.pdf). Sympatric ocelots and jaguars may be reducing little spotted cat (*Felis tigrina*) numbers (Oliveira 2005-Website).

Two ongoing ocelot studies include conservation genetics and surveys of large mammals in the Brazilian Atlantic Forest in the Pontal do Paranapanema region. The first study seeks to locate crucial areas and corridors for jaguar, puma, ocelot, lowland tapir, and white-lipped and collared peccaries (website: http://www.columbia.edu/~ag2027). The latter study will attempt to determine ocelot demographic status and develop a management plan for the region (website: http://www.rufford.org/rsg/Projects/AnaelAymoreJacob.html).

The Brazilian Ocelot Consortium (BOC) was initiated in 2002 as a conservation partnership under the auspices of the American Zoo and Aquarium Association's (AZA) Ocelot Species Survival Plan (SSP), Felid Taxon Advisory Group (TAG) and Brazil Conservation Action Partnership (CAP), in cooperation with Brazil's Permanent Committee for Conservation of Brazilian Felids, the Associaçao Mata Ciliar (AMC, a Brazilian NGO) and the Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA). The primary goal of the BOC was to identify issues affecting the survival of the Brazilian ocelot (*L. p. mitis*) and develop a comprehensive management strategy that addresses both *in situ* and *ex situ* conservation. It targets the ocelot as the ambassador for conserving all endangered Brazilian cats. Six priority projects were identified for funding to improve the genetic management of captive populations in both the U.S. and Brazil, and enhance *in situ* conservation and education in Brazil: 1) publication of Brazilian felid studbooks and husbandry manual; 2) training of Brazilian zoo staff and scientists; 3) captive propagation of Brazilian ocelots; 4) maintenance of a biological resource bank for Brazilian felids; 5) habitat restoration; and 6) environmental education (Swanson 2003; 2003a).

The BOC conservation strategy depends on monetary and in-kind support from Consortium participants, with financial and logistical oversight provided by a bi-national Consortium steering committee. To provide funding (a minimum of $90,000-$100,000) for all BOC projects, ten AZA institutions were recruited as full participants in the BOC, with additional support donated from other AZA institutions as partial participants. During each calendar year, funding from each full participant is divided proportionally among the funded projects. As one component of the BOC, each full participant will be allowed to import a breeding pair of ocelots from Brazil to assist the Ocelot SSP in establishing a founder population of this subspecies in U.S. zoos. Offspring from these founder pairs will be distributed preferentially to partial participants in the BOC and other AZA institutions. The ultimate goal is to manage the Ocelot SSP population and the Brazilian zoo population as a global metapopulation while maintaining strong linkages to *in situ* conservation efforts (Swanson 2003; 2003a).

From 2002-2006 the BOC supported forest restoration efforts in and around the Serra do Japi Biosphere Reserve in the State of Sao Paulo. In 2006 a camera trap survey in the Reserve was initiated to assess the resident carnivore community (ocelot, margay, tigrina, jaguarundi, and puma). Four ocelots were photographed over a short period of time, and based on ocelot densities in other regions of Brazil, it is estimated that as many as 225 ocelots may exist in the Reserve (BOC 2006).

COLOMBIA

The ocelot has been protected in Colombia since 1973 (CITES 2005: http://www.oaklandzoo.org/atoz/azocelot.html) where it inhabits mountainous areas (Guggisberg 1975). Colombia is the world's leading grower of coca plants and approximately 2,317 mi^2 (6,000 km^2) of forest have been cleared as of 2001 to supply the growing demand for cocaine (Castro-UNESCO 2001). The five-year Colombia Plan, created in 2001, is funded primarily by the U.S. to eradicate coca plantations using aerial spraying of the herbicide glyphosphate (Roundup) (Castro-UNESCO 2001, Colombian Embassy 2003). As of 2001, Roundup has been sprayed on >1,158 mi^2 (3,000 km^2) of coca plantations and adjacent farms and plantations (Castro-UNESCO 2001). Concerns of irreversible damage to plants and animals and water contamination from glyphosphate are being investigated (Castro-UNESCO 2001), although Mansanto claims that Roundup is not harmful to terrestrial organisms (http://www.mansanto.com/). Ecological impacts of glyphosphate have not been tested in large tropical ecosystems (Knight 2000). Habitat destruction from defoliation could negatively affect the ocelot and its prey.

ECUADOR

Ecuador offers no protection to the ocelot (Tewes et al. 2005). *Leopardus pardalis aequatorialis* was documented on the eastern side of the Andes in 1925 (Lonnberg 1925). In the tropical province of Pastaza, the largest of 22 provinces in Ecuador, Emmons (1984) looked for ocelots but did not find any. She attributed the absence of ocelots to hunting for at least 2 decades prior to the study (Emmons 1984).

The ocelot occurs in Pululahua National Monument in Pichincha province and in the Catacachi Cayapas Ecological Reserve of Imbabura province, both located on the forested western slopes of the Andes (http://www.ecuaworld.com/discover/reservas.htm, http://www.embaecuador-malaysia.com/tourism%20national%20parks.htm). Llanganates National Park, located in the highlands between the Andes and the Amazon lowlands, also supports the ocelot (http://www.lunaruntun.com/english/llanganates_national_park.htm http://link.lanic.utexas.edu/hemispheres/units/geography/ecuador_conservation.pdf).

FRENCH GUIANA

No studies of the ocelot in French Guiana or any references in the literature were located.

GUYANA

Guyana offers no protection to the ocelot (Tewes et al. 2005), and its status there is unknown.

PARAGUAY

Paraguay was the main export source for feline skins, including ocelot, in 1979 and 1980 (McMahan 1986). The Gran Chaco region, a vast plain shared by Argentina, Bolivia, Brazil, and Paraguay, is one of South America's largest ecoregions (Taber et al. 1997). Gran Chaco translates into "Great Hunting" (Redford and Eisenberg 1989) or "Hunting Land" and covers an area of 386,102 mi^2 (1,000,000 km^2) and contains high mammalian diversity (Taber et al. 1997). The Gran Chaco has been subjected to unsustainable land-uses including agriculture and hunting (Taber et al. 1997). The three National Parks in this region cover 4,247 mi^2 (11,000 km^2) and protect 3.1% of the Gran Chaco (Taber et al. 1997).

Four ocelots were encountered during a 1994-1996 study of the hunting impact on larger wildlife species in the 60,000 ha Mbaracayu Nature Reserve of Paraguay but no ocelots were reported killed by hunters between 1980 and 1996 (Hill et al. 1997). The Mbaracayu Nature Reserve is in the Atlantic rainforest of eastern Paraguay and contains 90% of all recorded species in the country (Hill et al. 1997). Although ocelots are not hunted by local tribes, poaching by non-native hunters occurs (Hill et al. 1997).

PERU

The ocelot was protected in 1973, making Peru one of the first countries to set a national standard for the species' conservation in South America (website: http://www.oaklandzoo.org/atoz/azocelot.html). Conflicting claims to land, poorly managed logging, road construction, and hunting in reserves may threaten the ocelot. Loggers have been supplied with guns or employ local hunters to kill large or unusual game (Naughton-Treves 2002). As in formerly inaccessible forests elsewhere, logging leads to settlement, slash and burn agriculture, and ranching.

Emmons (1984) did not record ocelots at Cocha Cashu Biological Station in Manu National Park, or Tambopata Reserve in northeastern Peru. She attributed these findings to recent overhunting of ocelots in the region. A later study at Cocha Cashu estimated 4 resident ocelots/5km^2 (2.07 ocelots/mi^2) (Emmons 1988). Home ranges of two adult females were 1.6 and 2.5 km^2 and home ranges of two adult males were 5.9 and 8.1 km^2 (Emmons 1988).

Ocelot activity decreased as the moon waxed in southeastern Peruvian lowland tropical rainforest, at Cocha Cashu Biological Station (Emmons et al. 1989). Ocelots avoided exposure to moonlight by taking alternate, darker routes or clustering their activity before moonrise or after moonset (Emmons et al. 1989).

Ocelot density at Cocha Cashu Biological Station was estimated at 2.07 ocelots/mi^2 (0.8/km^2) (Janson and Emmons 1990). The high density of ocelots was attributed to prey partitioning, the absence of human hunting, high primary productivity, and high regional biodiversity (Janson and Emmons 1990).

A study investigating rural development and typical hunting practices found ocelots were not killed in flooded forests. However, 0.01 to 0.13 ocelots/mi^2 (0.004 to 0.05/km^2) were killed in upland forest (Bodmer and Lozano 2001). Tourist markets in Iquitos offer illegal wild cat products, including pelts, teeth, and skulls, that are purchased primarily by U.S. military personnel (Bodmer and Lozano 2001). Meat from hunted carnivores was consumed locally in rural Peru (Bodmer and Lozano 2001).

Naughton-Treves et al. (2003) estimated an ocelot density of 2.07 ocelots/mi^2 (0.8/km^2) in the Tambopata-Candamo Reserve of southeastern Peru. Hunting of ocelots is permitted if livestock is threatened (Naughton-Treves et al. 2003). Local respondents to questionnaires blamed the ocelot for 32% of poultry and pig losses, followed by hawks (28%) and jaguar (5%) (Naughton-Treves et al. 2003). Ocelots used fallow fields more than expected, followed by forests, with a lower use of agricultural fields than either fallow fields or forests (Naughton-Treves et al. 2003). Use of fallow fields could be attributed to the greater amount of understory and the high abundance and diversity of small mammals. Naughton-Treves et al. (2003) classified the ocelot as “anthropogenic” fauna, capable of exploiting secondary vegetation if hunting is restricted.

SURINAME

No studies of the ocelot in Suriname or any references in the literature were found.

TRINIDAD

The ocelot occurs on this island (CITES 2005) but no additional information was available for this area.

URUGUAY

The ocelot was documented for the first time in Uruguay in 1988, extending its known range southward by 217 mi (350 km) (Ximénez 1988). Its population status is unknown.

VENEZUELA

The ocelot occurs throughout Venezuela in tropical dry forest, tropical humid forest, evergreen forest, and tropical dry thorn forest (Bisbal 1989). Tropical dry forest is the most extensive vegetation type in Venezuela (Bisbal 1989).

In addition to being a member of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Venezuela has its own laws protecting the ocelot. It was listed in the Official Venezuelan List of Game Animals under Total Protection in 1970, but the law is rarely enforced (Mondolfi 1986).

The ocelot occurs at lower altitudes from sea level to 3,280 ft (1000 m) (Mondolfi 1986). In gallery forest along a river adjacent to the Masaguaral cattle ranch, at least 23 ocelots occurred in an area also inhabited by jaguar, puma, and margay (Mondolfi 1986). The Masaguaral private ranch covers 20,000 ac (8,000 ha) and has been protected from hunters for 50 years. The ocelot occurs in over half of the 25 Venezuelan national parks, in two faunal reserves, and in one faunal refuge where the ocelot receives some protection. In forestry reserves, however, the ocelot is not protected and hunting occurs (Mondolfi 1986). Illegal shooting (done primarily at night with headlamps), baited traps, hunting with dogs, and habitat loss are the primary threats to the ocelot in Venezuela (Mondolfi 1986).

In the llanos region, located in central Venezuela, predator activity was dictated by the schedules and locations of preferred prey, and ocelots were recorded in open areas only at night (Sunquist et al. 1989). In seasonally flooded savannas, broken riparian forests, tropical deciduous forests, and sandhills of the Masaguaral ranch where the study was conducted, five ocelots were captured, radio-collared, and monitored. Sunquist et al. (1989) estimated an ocelot density of 2.59/mi^2 (1.0/km^2). Ludlow (1986) estimated ocelot density at 1.04/mi^2 (0.4/km^2) at the Masaguaral ranch. Ludlow and Sunquist (1987) estimated the ocelot density to be 0.98/mi^2 (0.38/km^2).

Farrell et al. (2000) found evidence of prey partitioning among the jaguar, puma, ocelot, and crab-eating fox at the Hato Pinero cattle ranch in the western Venezuelan llanos. Reptiles made up 43% of ocelot scat biomass, with small mammals, medium mammals, birds, and crabs also taken (Farrell et al. 2000). By consuming prey from all categories except large mammals and fish, the ocelot displayed a broader niche breadth than jaguar or puma (Farrell et al. 2000).

CONCLUSION

As a widespread species with low population densities, the ocelot will require international cooperation to ensure its long-term survival. The ocelot seems tolerant of human settlement, but is susceptible to over-hunting. It requires areas with relatively dense cover. The ocelot may adapt to changing habitats if there is adequate cover and limited fragmentation.

Some ocelot populations have rebounded since the decline of the fur trade. However, poverty, rural development, subsistence hunting, poaching, logging, and extraction of forest products present current challenges to the ocelot. Wildlife conservation in impoverished regions will be more successful if it does not create short-term losses to local livelihoods, such as a reduction in harvests of wild species upon which a community's economic status depends (Bodmer and Lozano 2001). Land uses compatible with earning a sustainable livelihood and maintaining areas for ocelots, such as shade-grown coffee plantations or harvesting nuts or other resources from intact forests, benefit both people and wildlife. Balancing economic incentives with ocelot habitat protection will likely foster more effective local survival and global conservation for the ocelot.

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Appendix IV – Ocelot Population Viability Analysis

Preliminary Population Viability Assessment for the Ocelot (*Leopardus pardalis*) In South Texas and Northern Tamaulipas

Report prepared by:

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In collaboration with

Members of the

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Preliminary Population Viability Assessment for the Ocelot (*Leopardus pardalis*) In South Texas and Northern Tamaulipas

Philip Miller, Conservation Breeding Specialist Group
and
U.S. Fish and Wildlife Service Bi–National Ocelot Recovery Team Members

TABLE OF CONTENTS

Preliminary Population Viability Assessment for the Ocelot (*Leopardus pardalis*) In South Texas and Northern Tamaulipas

Philip Miller, Conservation Breeding Specialist Group
and
U.S. Fish and Wildlife Service Bi–National Ocelot Recovery Team Members

Introduction

In 1990, the USFWS published *The Listed Cats of Texas and Arizona Recovery Plan (With Emphasis on the Ocelot)* through the United States Fish and Wildlife Service. While considerable progress was made over the last decade in conducting ocelot research, there are a number of recovery actions that have received little attention following the publication of this important document. In addition the geographic, economic, and political landscapes in south Texas and northern Tamaulipas have changed considerably since 1990, thereby necessitating a review and probably revision of the Plan's information and recommended actions. In response to this need, an Ocelot Recovery Team was formed in May 2003 for the purpose of revising the outdated plan. The team is composed of both a Technical and an Implementation subgroup with representation from the United States and Mexico.

The 1990 recovery plan recommended some major demography-related activities for ocelot recovery, namely "determining the precise population sizes and habitat sizes required for viability and the necessary spatial arrangement of habitat, and determining the impact of disease and other factors on the population; increasing ocelot numbers in Texas, in part by protecting at least 20,000 hectares of prime ocelot habitat in Texas (either in a single block or continuous blocks connected by corridors)." Population viability analysis (PVA) has been identified by the Recovery Team as a valuable tool for determining the likely fate of the ocelot populations currently distributed throughout south Texas and northern Tamaulipas, and to assist in the process of identifying the most promising recovery actions.

A PVA can be an extremely useful tool for investigating current and future risk of wildlife population decline or extinction. In addition, the need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing populations of the ocelot in its wild habitat in south Texas and northern Tamaulipas. *VORTEX*, a simulation software package written for population viability analysis, was used here as a mechanism to study the interaction of a number of ocelot life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

The *VORTEX* package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by stepping through the series of events that describe the typical life cycles of sexually reproducing, diploid organisms.

PVA methodologies such as the *VORTEX* system are not intended to give absolute and precise "answers," since they are projecting the interactions of many randomly-fluctuating parameters used as model input and because of considerable measurement uncertainty we observe in typical wildlife population demography datasets. Because of these limitations, many researchers have cautioned against the sole use of PVA results to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of the output depends upon our knowledge of the biology of the ocelot in this portion of its habitat, the environmental conditions affecting the species, and possible future changes in these conditions. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Appendix I below, Lacy (2000) and Miller and Lacy (2003).

Specifically, we were interested in using this preliminary analysis to address the following questions:

- What is our best estimate of stochastic population dynamics of the ocelot within its current range in south Texas and northern Tamaulipas?
- What are the primary factors that drive population growth dynamics of ocelots in south Texas and northern Tamaulipas?
- How vulnerable are small, fragmented populations of ocelots in south Texas and northern Tamaulipas to local extinction in the absence of demographic interaction with other populations?
- What are the benefits to the ocelot of increasing range and connectivity in the landscape?
- How successful might translocation be as a conservation management strategy for smaller populations of ocelots in south Texas?
- How many individuals could be removed from a given source population such as northern Tamaulipas for translocation into smaller populations in south Texas at risk of extinction without negatively impacting the persistence of the source?

The *VORTEX* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies.

Baseline Input Parameters for Stochastic Population Viability Simulations

The relatively scarce data on the population biology and ecology of the ocelot in the northern extreme of its global range comes primarily from Tewes and Schmidly (1987), Laack (1991), Caso (1994), and López Gonzalez et al. (2003). Moreover, the recent analyses of A. Haines (Texas A&I, Kingsville) proved valuable in the development of appropriate model input parameters. Discussion of baseline model input focused on our understanding of the ocelot population within the Laguna Atascosa National Wildlife Refuge, Cameron County, Texas. Where data were absent, we utilized similar information from captive populations and from studies focused on other geographic areas.

Breeding System: Ocelots will often form stable breeding groups that remain intact over more than one year. Therefore, we used the "long-term polygyny" option within *VORTEX* to model this breeding system. Under this option, a set of adult females are therefore randomly selected each year to breed with a given male. Pairs that are produced in a given year are then retained in future years until one of the mates dies.

Age of First Reproduction: *VORTEX* considers the age of first reproduction as the age at which the first kittens are born, not simply the onset of sexual maturity. All available information indicates wild female ocelots produce their first offspring no earlier than about 30 months of age. We therefore set this parameter at three years. In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with this variable set to either two years or four years of age. Because males must typically wait for the opportunity to fill vacancies within a given territory, their age of first reproduction is typically older. We set this parameter to four years in all models.

Age of Reproductive Senescence: In its simplest form, *VORTEX* assumes that animals can reproduce (at the normal rate) throughout their adult life. There are no real data available on senescence in ocelots. Captive animals have lived up to 15-17 years, but it is quite likely that this cannot be achieved under much more competitive conditions in the wild. We therefore estimated that ocelots could live up to 11 years in the wild. In reality, achieving this age is unlikely given mortality rates (see below). In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with this variable set to either 9 or 13 years of age.

Offspring Production: Based on our knowledge of ocelot life history, we have defined reproduction in these models as the production of kittens observed in the field. Indirect evidence suggests that ocelots often breed every other year, but there are no direct data of this type in south Texas/northern Tamaulipas. Our best "guesstimate" of the average percentage of adult females that successfully breed per year was therefore set at 50%. There are some data (Laack et al, in press) to suggest that this value is an underestimate, although data to the contrary are sparse and difficult to interpret conclusively. In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with this variable set to a higher value of 75%.

Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully produce kittens within a given year. While no data are available for this parameter, we propose that annual variance is relatively low. We therefore set the standard deviation in the percentage of adult females breeding at 5%.

Many studies have cited an average ocelot litter size of about 1.4 – 1.5 kittens per successful female. We developed the following distribution of possible litter sizes for a given successful female:

Number of kittens	%
1	66.0
2	33.0
3	1.0

This distribution yields an average litter size of 1.35 kittens. Litters of three individuals are thought to be possible but quite rare. In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with a reversed distribution of litters of size 1 and 2, thereby giving a new average litter size of 1.68. The overall population-level sex ratio among newborns is assumed to be 50%.

Density-Dependent Reproduction: *VORTEX* can model density dependence with an equation that specifies the proportion of adult females that reproduce as a function of the total population size. In addition to including a more typical reduction in breeding in high-density populations, the user can also model an Allee effect: a decrease in the proportion of females that bread at low population density due, for example, to difficulty in finding mates that are widely dispersed across the landscape.

At this time, there are no data to support density dependence in reproduction in ocelot populations occupying this portion of their range. Consequently, this option was not included in the models presented here. It is possible that population decreases could actually stimulate higher levels of reproductive success through a decline in intraspecific competition; the detailed mode of action of this relationship, however, was not determined for this analysis.

Male Breeding Pool: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered "available" for breeding each year. Within any given year, we assume that all adult male ocelots are equally capable of siring offspring; this is not to say, however, that all adult males actually meet with the same level of success during a given breeding season.

Mortality: Age-sex-specific mortality rates for this PVA are based on new analyses by Aaron Haines. When developing a mortality schedule for ocelots in south Texas, it is vitally important to separate out the impact of road-kill mortality from background mortality. Vehicle impacts are a major source of mortality in this geographic area, especially among subadult individuals that are attempting to disperse to new territories. From the available field and Haines' analysis, we have developed the following schedules, with and without the effect of vehicle-impact mortality:

Age Class	% Mortality (SD) (Road mortality excluded)		% Mortality (SD) (Road mortality included)	
	Females	Males	Females	Males
0 – 1	30.0 (6.0)	30.0 (6.0)	33.0 (7.0)	33.0 (7.0)
1 – 2	15.0 (3.0)	15.0 (3.0)	15.0 (3.0)	15.0 (3.0)
2 – 3	16.0 (4.0)	30.0 (6.0)	30.0 (7.0)	37.0 (8.0)
3 – 4	8.0 (2.0)	13.0 (3.0)	13.0 (3.0)	13.0 (3.0)
4+	8.0 (2.0)	8.0 (2.0)	13.0 (3.0)	13.0 (3.0)

Note the high levels of mortality among 2-3 year-olds, especially among males. In addition, Haines' analysis indicates the significant effect that vehicle impacts have on the mortality of dispersing females in this same age class. Under these conditions, the probability of a female reaching reproductive age is about 50% in the absence of road mortality, but this drops to 40% when road mortality is included. Similarly, the probability of a female reaching the maximum age drops from about 24% in the absence of road mortality to about 12% in the presence of road mortality.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence and a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect), and are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values.

We suspected that a drought event could severely affect the reproductive capability of adult females. Therefore, we included a drought catastrophe in many of our models. Calculations by Haines at the workshop suggested that such a severe event would occur approximately once every 9-10 years, so we assumed that the annual probability of such an event occurring was 11%. We also assumed that such a drought would reduce the population-level measure of reproductive success (percentage of adult females breeding each year) by 50%. In other words, if approximately 50% of adult females bred successfully in a year without drought, only about 25% would be expected to do so during a serious drought. In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with the drought event removed from the analysis.

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. While specific data on inbreeding depression in either captive or wild ocelot populations were not available for this analysis, the preponderance of evidence for the deleterious impacts of inbreeding in mammal populations suggests that it can be a real factor in small populations of ocelots. We therefore elected to include this process in our models, with a genetic load of 3.14 lethal equivalents and approximately 50% of this load expressed as lethal genes. In order to test the sensitivity of our models to uncertainty in this parameter, we ran additional models with inbreeding depression removed from the analysis.

Initial Population Size: Estimates at the time this model was run put the total ocelot population size within the Laguna Atascosa National Wildlife Refuge (LANWR) in Cameron County at approximately 30 individuals, while the population occupying the lands in Willacy and Kenedy Counties is considered to be slightly larger (i.e., around 40 individuals). The closest population in Mexico, approximately 130 km to the south in Tamaulipas, is thought to be about 200 animals. These values were used for specific models designed to evaluate the risk of extinction of existing populations.

Because of the uncertainty in these estimates, and because of a greater interest in the more general results that can be obtained from a systematic analysis of population size and its influence on persistence in the face of random demographic fluctuations in ocelot populations, we decided to also focus on a set of population size classes throughout the analysis. The size classes studied were:
N_0 = 30, 40, 50, 60, 75, 100, 150, 200

VORTEX distributes the specified initial population among age-sex classes according to a stable age distribution that is characteristic of the mortality and reproductive schedules described previously.

Carrying Capacity: The carrying capacity, or K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across all age classes in order to return the population to the value set for K.

All observations suggest that, through the action of habitat alteration and destruction by local human activities, ocelot populations in south Texas and northern Tamaulipas are at or very near their ecological carrying capacity within existing habitat. Therefore, we initialized all our models with K equal to the appropriate initial population size.

Metapopulation Analysis: An important issue for management of ocelot in the northern extent of their range is the feasibility of "linking" the three populations mentioned above by artificial dispersal, i.e., translocation. Natural dispersal has not been observed in this part of their range and does not appear to be a realistic expectation at this time. To evaluate artificial dispersal as a conservation tool, we developed a set of simulations that involved the removal of four 2-year-old animals (equal sex ratio) – those that have the highest probability of mortality through natural dispersal and associated vehicle impacts – from the Tamaulipas population every other year and distributing them into the two United States populations. During this process, we assume a 50% loss of individuals during transport, so that only one ocelot is being added to each of the LANWR and Willacy-Kenedy populations during the process. Moreover, we assume that this process can not last forever, so we continue the process at 2-year intervals for either 30 or 60 years. In addition to assessing the efficacy of this procedure for potential "rescue" of the much smaller United States populations, we also want to evaluate the impact that such a rate of removal might have on the source Mexican population.

Iterations and Years of Projection: All population projections (scenarios) were simulated 500 times. Each projection extends to 100 years, with demographic information obtained at annual intervals. All simulations were conducted using *VORTEX* version 9.45 (June 2004).

Table 1 below summarizes the baseline input dataset upon which all subsequent *VORTEX* models are based.

Table 1. Demographic input parameters for the baseline *VORTEX* models for populations of ocelot in south Texas and northern Tamaulipas. See accompanying text for more information.

Model Input Parameter	Baseline value
Breeding System	Long-term polygynous
Age of first reproduction (♀ / ♂)	3 / 4
Maximum age of reproduction	11
Inbreeding depression?	Yes
Lethal equivalents	3.14
Annual % adult females reproducing (SD)	50
Density dependent reproduction?	No
Maximum litter size	3
Mean litter size†	1.35
Overall offspring sex ratio	0.5
Adult males in breeding pool	100%
% annual mortality, ♀ / ♂ (SD)	
0 – 1	33.0 / 33.0 (7.0)‡
1 – 2	15.0 / 15.0 (3.0)
2 – 3	30.0 / 37.0 (8.0)
3 – 4	13.0 / 13.0 (3.0)
4 – +	13.0 / 13.0 (3.0)
Catastrophe?	Drought
Annual frequency of occurrence	11%
Severity: Reproduction	0.5
Severity: Survival	1.0
Initial population size / K	
Laguna Atascosa (LANWR)	30 / 30
Willacy – Kenedy Counties	40 / 40
Tamaulipas, Mexico	200 / 200

† Exact probability distribution of individual clutch size specified in input file.
‡ Includes road mortality; see text for specification of natural mortality levels.

Results of Baseline Simulation

Results reported for each modeling scenario include:

$\underline{r_s}$ (SD) – The mean rate of stochastic population growth or decline (standard deviation) demonstrated by the simulated populations, averaged across years and iterations, for all simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity.

$\underline{P(E)_{100}}$ – Probability of population extinction after 100 years, determined by the proportion of 500 iterations within that given scenario that have gone extinct within the given time frame. "Extinction" is defined in the *VORTEX* model as the absence of either sex.

$\underline{N_{100}}$ (SD) – Mean (standard deviation) population size at the end of the simulation, averaged across all simulated populations, including those that are extinct.

$\underline{GD_{100}}$ – The gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity.

T(E) – The average time to population extinction, in years.

The set of demographic, genetic, and ecological input data that represents our best understanding of the life history of ocelots in south Texas is hereafter referred to as our *baseline model*. This model simulates the predicted trajectory of a small population inhabiting Laguna Atascosa NWR when all sources of mortality – both natural and anthropogenic – are included. The results of this analysis are presented in Figure 1 below. The average population growth rate is -0.082, and the extinction probability over 100 years is 100%.

It is clear from this Figure that, under our best estimates of ocelot population biological parameters, the population currently occupying Laguna Atascosa NWR is expected to decline rapidly toward extinction within the next 50 years. The high rate of decline seen in the model is no doubt due at least in part to pessimistic estimates of certain key demographic parameters, such as the age of first reproduction or the percentage of adult female breeding success. In other words, we may be assuming that females begin breeding at an age that is older than the real situation in the wild, and we may be underestimating the rate of breeding success among adult females. However, this decline also surely results from a more accurate portrayal of other tangible consequences of ocelot biology and local anthropogenic activity, including:

- habitat loss around LANWR that leads to a very small suitable area and an associated small ocelot population subjected to stochastic demographic fluctuations;
- "frustrated dispersal," with a significant proportion of dispersing individuals killed while attempting to move across compromised habitat in search of new territories; and
- increased mortality through vehicle impacts.

The working group developing this model concludes that, while perhaps more severe in absolute magnitude compared to the actual situation in the wild, our simulation model of ocelot population dynamics within LANWR is a fairly accurate simulation of the likely fate of this population in the absence of intensive management.

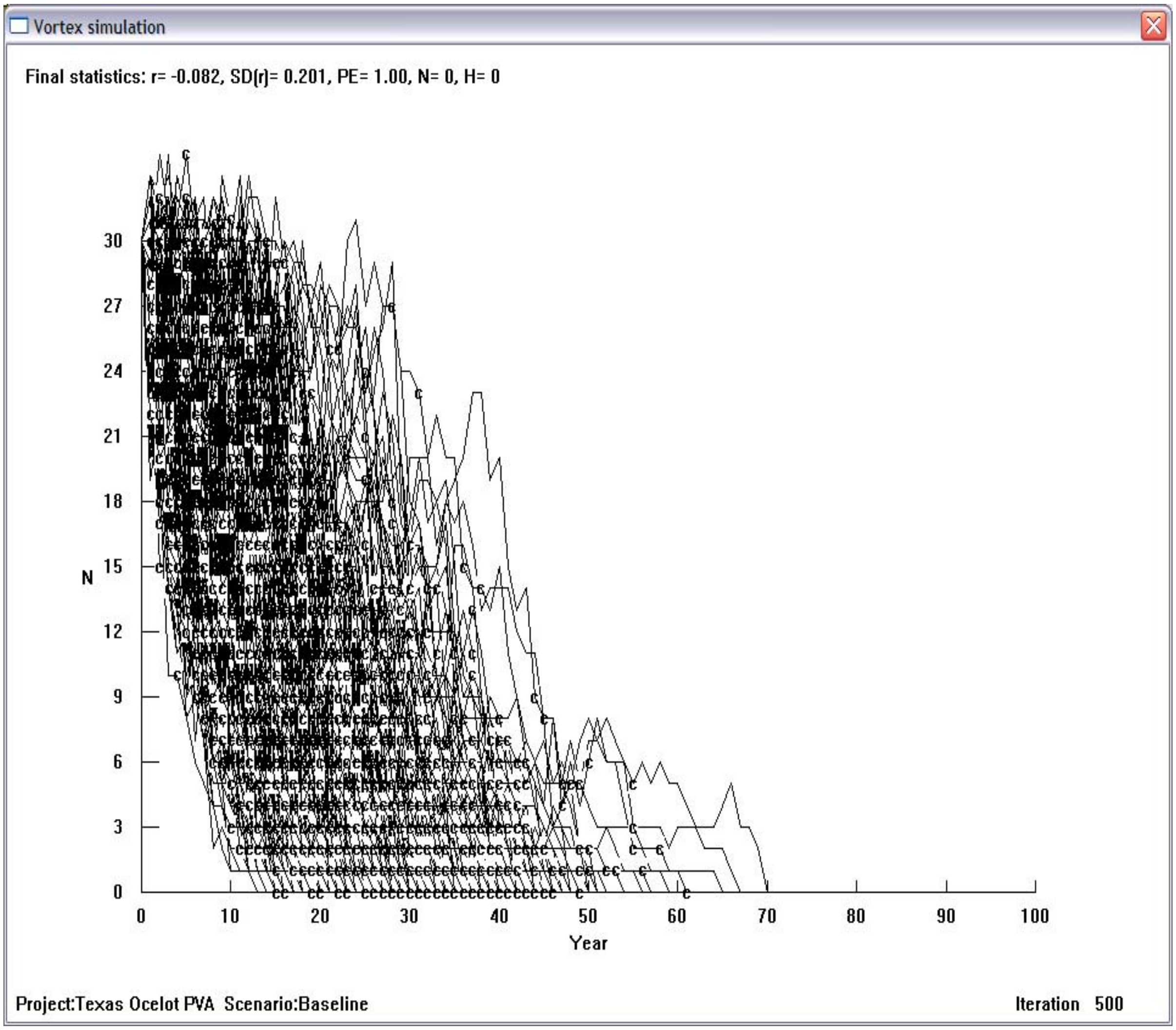


Figure 1. Plot of 500 individual iterations of the baseline *VORTEX* model of predicted ocelot population dynamics in Laguna Atascosa National Wildlife Refuge, Texas. The average rate of population growth across these iterations is -0.082, indicating a considerable rate of decline with extinction occurring within 40 years. Note the level of variance in the model as defined by both demographic and environmental sources of stochasticity included

Demographic Sensitivity Analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of ocelot populations in south Texas and northern Tamaulipas were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identify a selected set of parameters from Table 1 whose estimate we see as considerably uncertain. We then develop biologically plausible minimum and maximum values for these parameters (see Table 2).

Table 2. Uncertain input parameters and their stated ranges for use in demographic sensitivity analysis of simulated ocelot populations in south Texas and northern Tamaulipas. Values in bold are those used in the baseline model. See accompanying text for more information.

		Estimate	
Model Parameter	Minimum	Midpoint	Maximum
Age of First Reproduction	2	**3**	4
Maximum Age	9	**11**	13
Inbreeding Depression	No	**Yes**	
% Adult Females Reproducing		**50**	75
Average Litter Size		**1.35**	1.68
Road Mortality	No	**Yes**	
Drought	No	**Yes**	

For each of these parameters listed above we construct multiple simulations, with a given parameter set at its prescribed minimum and/or maximum value, with all other parameters remaining at their baseline value. With the 7 parameters identified above, and recognizing that the aggregate set of baseline values constitute our single baseline model, the table above allows us to construct a total of 10 additional, alternative models whose performance (defined, for example, in terms of average population growth rate) can be compared to that of our starting baseline model. For the entire suite of sensitivity analysis models, we will consider a population very similar to that occupying Laguna Atascosa NWR, i.e., initial population size and ecological carrying capacity equal to 30 individuals.

The results of the sensitivity analysis are shown graphically in Figure 2 and in tabular form in Table 3.

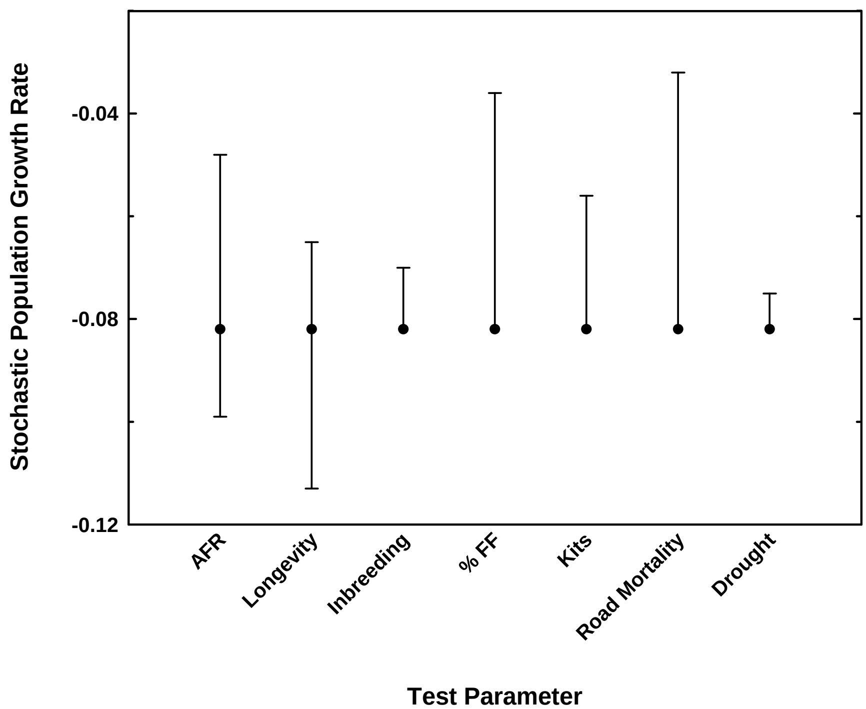


Figure 2. Demographic sensitivity analysis of a simulated LANWR ocelot population. Stochastic population growth rate for a set of models in which the specific parameter is varied across a range of biologically plausible values. The baseline model growth rate of -0.082 is given by the central data point for each parameter. The general model of ocelot population dynamics is most sensitive to uncertainty in those parameters giving the widest range in simulated population growth rates. See text for additional details.

Table 3. South Texas / northern Tamaulipas ocelot PVA. Output from demographic sensitivity analysis models. See text for additional information on model construction and parameterization.

Model conditions	**r_s (SD)**
Baseline	-0.082 (0.201)
Age of First Reproduction	
2	-0.048 (0.188)
4	-0.099 (0.205)
Maximum Breeding Age	
9	-0.113 (0.209)
13	-0.065 (0.191)
Inbreeding Depression	
No	-0.070 (0.204)
% Adult Females Breeding	
75	-0.036 (0.186)
Litter Size	
1.68	-0.056 (0.198)
Road Mortality	
No	-0.032 (0.168)
Drought	
No	-0.075 (0.195)

It is clear from the analysis that our model of ocelot population dynamics is most sensitive to uncertainty in adult female reproductive success (defined here as the percentage of adult females that successfully produce a litter) and to additional mortality of ocelots through vehicle impacts. Uncertainty in reproductive lifespan also leads to significant model response, but not to the level of that seen among the aforementioned variables. While in exclusion of inbreeding depression does not significantly alter the results of our baseline model, we are reluctant to discount its potential impact in small or isolated populations of ocelots in the periphery of the species' range. There is an abundance of evidence suggesting that small populations of mammals can suffer markedly from the impacts of inbreeding depression; there are simply too many other factors conspiring to drive this population into rapid decline for us to be able to discern the precise action of this genetic factor in our particular model.

Once the generalized sensitivity analysis was successfully completed, we set out to develop a set of models with the goal of more precisely identifying the relative contributions of adult and juvenile mortality to the overall growth dynamics of our simulated ocelot population. This was done in order to provide a better understanding of species population dynamics, to define a broad set of minimal conditions necessary to increase the chances of population persistence, and to gain additional insight into the magnitude of any detrimental impact of proposed major mortality factors. This type of analysis can provide a simple benchmark to which wild population management and associated field monitoring efforts can then be directed.

A total of 50 individual models were constructed that provided all possible combinations of 2 levels of reproductive success, 5 levels of juvenile mortality, and 5 levels of adult mortality. This was done in order to more effectively address the relationship between reproductive success and age-specific mortality required for population growth.

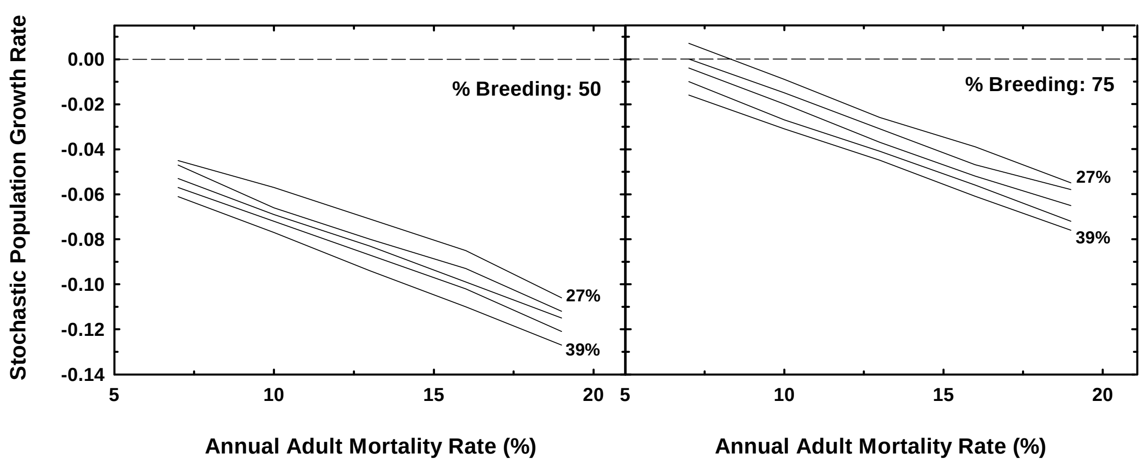


Figure 3. South Texas / northern Tamaulipas ocelot population mortality analysis. Plots give average stochastic population growth rate (r_s) as a function of annual mortality rate of adults with individual lines corresponding to different levels of juvenile mortality. Two panels correspond to variable levels of adult female reproductive success (see text for additional details on the determination of success). Initial population size for all simulations is set at 30 individuals.

The results of this mortality analysis are shown in Figure 3 above. It is clear that, under the conditions modeled here, only a very small number of combinations of juvenile and adult mortality can result in a population that is expected to grow over time (i.e., $r > 0.0$). Inspection of these graphs lead to the following additional conclusions:

- Nearly all simulated populations have negative growth rates, with many showing high rates of decline. Based on our understanding of the growth dynamics exhibited in the baseline model described earlier in this section, this poor level of population performance most likely reflects the high mortality present in small, isolated ocelot populations subjected to abnormal levels of vehicle impacts.
- Higher levels of reproductive success result in considerably higher levels of stochastic population growth under the same suite of mortality values. Nevertheless, the relatively high levels of vehicle-impact mortality present in the subadult (dispersing) stages included here reduce overall growth rates so that population growth is possible only under the most optimistic mortality schedule.
- A given percentage change in ocelot adult mortality results in a proportionally much larger change in mean population growth rate compared to a change in juvenile mortality of the same magnitude. In other words, the results of our simulation models are considerably more sensitive to adult mortality.

While it is very instructive to investigate the sensitivity of our model to uncertainty in demographic input, it is also important to recognize that detecting mortality rates to the level of precision discussed here is rather impractical at best. For example, statistical power analyses conducted on typical types of field demographic and survey data (e.g., Forcada 2000) suggest that either large sample sizes (say, in the hundreds of individuals) or long periods of observation (10 – 15 years) are necessary to detect meaningful changes in population numbers in the short term with reasonable levels of precision. Similarly, very large and detailed field studies would be required to successfully differentiate between, for example, juvenile mortality rates of 27% and 30%. Consequently, the analysis presented here should typically be used at a more "strategic" level. When faced with the need for population management in the face of measurement uncertainty and limited institutional resources, research and/or management prioritization can be accomplished through a comparative study of sensitivity analysis data. Having said this, it is also important to note that those parameters to which a demographic model is most sensitive may <u>not</u> be the same parameters that are most directly affected by human activities and are therefore putting the population at risk. Successful conservation requires careful additional study to identify the specific risks the populations face and to develop appropriate remedial actions. In the case of the ocelot in south Texas, however, we may in fact have a more direct relationship between the primary demographic drivers influencing population growth dynamics and the anthropogenic factors leading to population endangerment. The next section will explore these relationships in greater detail.

Risk Analysis I: Population Size, Road Mortality, and Extinction Risk

With our demographic sensitivity analysis complete, our next task was to investigate the relationship between the size of an ocelot population and its vulnerability to extinction in the presence of significant anthropogenic disturbance. To do this, we ran simulations for each initial population size discussed in the Input Parameters section across each of three alternative values of female reproductive success, deemed to be one of the most sensitive parameters in our model. This yields a total of 24 different model scenarios. To investigate the impact of road mortality, we then repeated this set of models but removed the additional mortality brought about through vehicle impacts – thereby producing a grand total of 48 models for analysis.

Essentially, our goal in this analysis is to identify, for a given scenario of assumed ocelot demography, the minimum population size necessary to reduce the risk of extinction below a defined threshold. Unfortunately for us biologists, the identification of this extinction threshold is based more on political and social factors than on anything else. The agreement upon a threshold must be done within a more participatory framework that includes a diversity of perspectives among those involved in the management and utilization of the taxon under study.

Table 4 and Figure 4 present the aggregate results of this analysis. Examination of these results lead us to the following conclusions:

- Road mortality has a considerable impact on the estimated viability of our simulated ocelot populations. When this additional mortality source is included, even the largest populations experience rapid population decline and very high extinction probabilities over the 100-year time span of the simulations. Average time to extinction varies from 25 – 50 years. When this additional mortality source is removed, overall population growth rates rebound markedly.
- In the absence of road mortality, small ocelot populations still have a considerable risk of extinction. This results from the detrimental impact of stochastic variability in demographic rates, leading to a general level of population instability and a subsequent reduction in growth potential.
- Under conditions of low reproductive success – i.e., when only 50% of adult females successfully produce a litter in any given year – ocelot populations have a significantly lower growth potential. In fact, inspection of these data indicate that when road mortality is present, the risk of population extinction in 100 years drops below 50% only under the most favorable conditions modeled here: a relatively large population of 150 – 200 individuals with the highest level of female reproductive success (70%). Even here, however, the average growth rate is about -0.025 and the final population size is reduced from the initial value by approximately 80%.

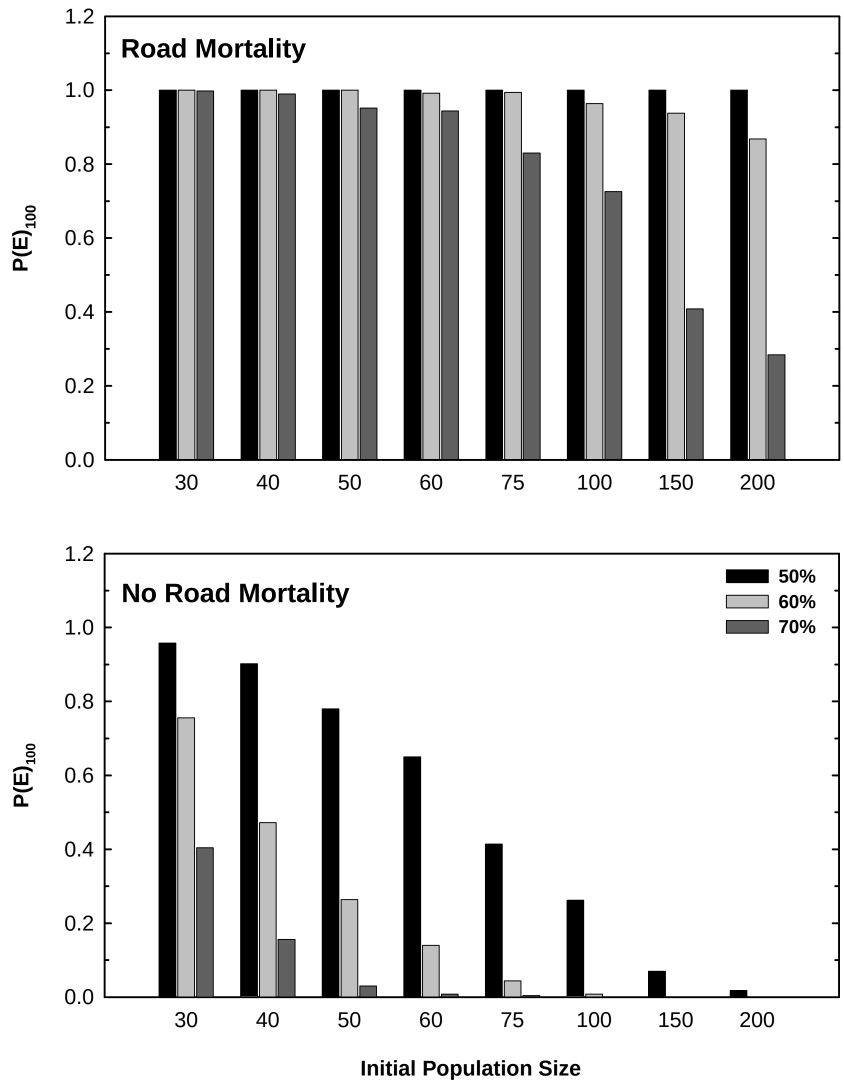
Table 4. South Texas/northern Tamaulipas ocelot PVA. Results of population size risk analysis models in the presence (top half) and absence (bottom half) of road mortality and under alternative conditions of underlying female reproductive success. See page 7 for definitions of column headings.

% ♀♀	**N_0**	**r_s (Obs) (SD)**	**$P(E)_{100}$**	**N_{100} (SD)**	**GD_{100}**	**T(E)**
Road Mortality						
50	30	-0.082 (0.199)	1.000	–	–	25
	40	-0.085 (0.199)	1.000	–	–	29

	50	-0.084 (0.192)	1.000	–	–	32
	60	-0.082 (0.182)	1.000	–	–	34
	75	-0.080 (0.175)	1.000	–	–	38
	100	-0.078 (0.168)	1.000	–	–	43
	150	-0.078 (0.160)	1.000	–	–	48
	200	-0.077 (0.156)	1.000	–	–	52
60	30	-0.062 (0.195)	1.000	–	–	31
	40	-0.061 (0.187)	1.000	–	–	37
	50	-0.059 (0.179)	1.000	–	–	41
	60	-0.057 (0.173)	0.992	6 (2)	0.436	47
	75	-0.057 (0.167)	0.994	9 (6)	0.596	51
	100	-0.056 (0.163)	0.964	7 (5)	0.446	57
	150	-0.053 (0.152)	0.938	12 (15)	0.543	69
	200	-0.050 (0.146)	0.868	13 (11)	0.653	78
70	30	-0.047 (0.194)	0.998	2 (–)	0.000	39
	40	-0.042 (0.180)	0.990	8 (2)	0.354	48
	50	-0.039 (0.170)	0.952	10 (7)	0.544	58
	60	-0.038 (0.165)	0.944	13 (9)	0.573	65
	75	-0.034 (0.157)	0.830	14 (11)	0.590	73
	100	-0.033 (0.150)	0.726	18 (16)	0.608	83
	150	-0.026 (0.131)	0.408	31 (28)	0.729	80
	200	-0.023 (0.123)	0.284	44 (39)	0.780	82
No Road Mortality						

50	30	-0.033 (0.169)	0.958	8 (4)	0.379	50
	40	-0.030 (0.159)	0.902	11 (9)	0.476	61
	50	-0.026 (0.148)	0.780	15 (11)	0.547	79
	60	-0.023 (0.139)	0.650	17 (13)	0.609	73
	75	-0.019 (0.127)	0.414	21 (17)	0.645	76
	100	-0.014 (0.114)	0.262	35 (25)	0.731	81
	150	-0.007 (0.096)	0.070	64 (40)	0.830	87
	200	-0.003 (0.087)	0.018	102 (53)	0.879	92
60	30	-0.011 (0.160)	0.756	11 (7)	0.465	64
	40	-0.002 (0.143)	0.472	20 (11)	0.566	74
	50	0.003 (0.128)	0.264	28 (14)	0.648	77
	60	0.007 (0.117)	0.140	35 (17)	0.693	79
	75	0.014 (0.105)	0.044	52 (21)	0.762	83
	100	0.019 (0.095)	0.008	77 (23)	0.827	81
	150	0.025 (0.087)	0.000	130 (24)	0.888	–
	200	0.028 (0.083)	0.000	180 (25)	0.917	–
70	30	0.013 (0.150)	0.404	18 (8)	0.497	71
	40	0.023 (0.131)	0.156	28 (11)	0.599	77
	50	0.032 (0.115)	0.030	40 (11)	0.684	89
	60	0.036 (0.109)	0.008	50 (12)	0.731	84
	75	0.041 (0.102)	0.004	70 (11)	0.795	74
	100	0.045 (0.095)	0.000	93 (11)	0.838	–
	150	0.050 (0.090)	0.000	144 (10)	0.892	–
	200	0.052 (0.087)	0.000	194 (12)	0.918	–

Figure 4. South Texas / northern Tamaulipas ocelot PVA. 100-year extinction probabilities for simulated populations of different initial sizes in the presence (top panel) and absence (bottom panel) of road mortality and under alternative conditions of adult female reproductive success (indicated by bar shading; see legend in bottom panel). See text for additional model information.

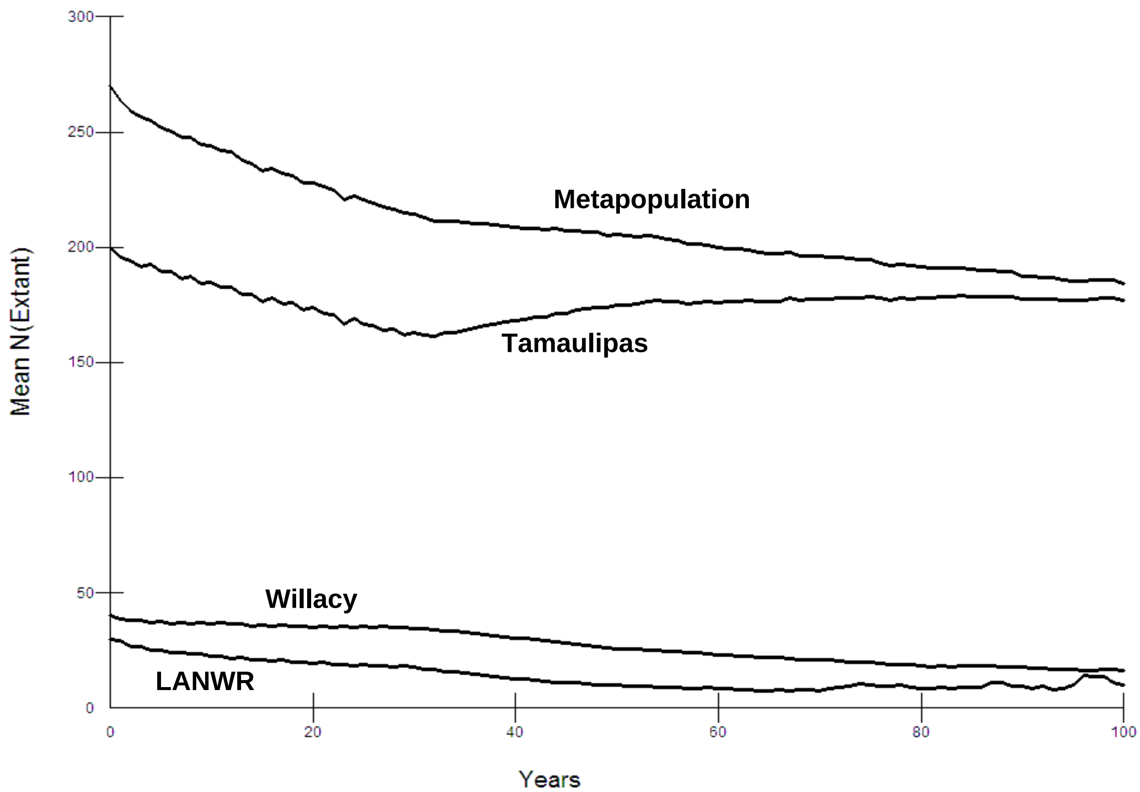


Taken together, these data reinforce the results obtained in our earlier demographic sensitivity analysis: uncertainty in our understanding of intrinsic ocelot breeding rates, and in our understanding of the quantitative impact of road-kill mortality, impairs our ability to make more precise predictions of the fate of ocelot populations subject to human activities. Nevertheless, models like these are invaluable in pointing out the relative importance of these factors in determining the persistence of these populations as humans encroach on their habitat with greater frequency and severity.

Risk Analysis II: Translocation and Metapopulation Viability

A representative population trajectory for each of the metapopulation components is presented in Figure 5, while the full results of the metapopulation analysis are presented in Table 5.

Figure 5. South Texas / northern Tamaulipas ocelot PVA. Representative translocation / metapopulation projection for 100 years, with translocation from Tamaulipas to the two U.S. populations occurring every other year for 30 years. Road mortality is included in this particular model, with a medium level of adult female reproductive success (60% of adult females are assumed to produce a litter each year). See accompanying text for additional model details.



Examination of these data lead us to the following conclusions:

- Even when translocation is used as a conservation strategy, the smaller South Texas populations are at a very high risk of population extinction when road mortality is included in the models. Bi-annual translocations from Tamaulipas are not sufficient to counteract the loss of individuals from vehicle impacts and the population decline resulting from stochastic fluctuations in demographic rates that is characteristic of small populations. When road mortality is removed from the analysis, and we assume a medium level of female reproductive success, all population growth rates are positive and extinction risks are greatly reduced.

Table 5. South Texas / northern Tamaulipas ocelot PVA. Results of metapopulation risk analysis models in the presence (top half) and absence (bottom half) of road mortality and under alternative conditions of underlying female reproductive success. See page 122 for definitions of column headings.

Years	% ♀♀	Population	r_s (Obs) (SD)	$P(E)_{100}$	N_{100} (SD)	GD_{100}	T(E)
30	50	LANWR	-0.048 (0.194)	1.000	–	–	42
		Wilacy	-0.023 (0.154)	0.910	9 (8)	0.487	71
		Tamaulipas	-0.022 (0.109)	0.288	64 (51)	0.796	75
		Metapop	-0.023 (0.099)	0.270	64 (51)	0.798	81
60		LANWR	-0.032 (0.195)	0.994	4 (3)	0.268	56
		Wilacy	-0.011 (0.143)	0.566	13 (8)	0.628	86
		Tamaulipas	-0.054 (0.137)	0.824	24 (26)	0.698	60
		Metapop	-0.034 (0.114)	0.458	18 (19)	0.669	88
30	60	LANWR	-0.033 (0.188)	0.996	10 (8)	0.612	50
		Wilacy	-0.004 (0.145)	0.568	16 (11)	0.578	79
		Tamaulipas	0.018 (0.082)	0.004	177 (33)	0.909	97
		Metapop	0.016 (0.075)	0.004	184 (35)	0.915	97
60		LANWR	-0.022 (0.188)	0.958	7 (4)	0.481	73
		Wilacy	0.012 (0.131)	0.152	20 (11)	0.683	90
		Tamaulipas	0.003 (0.096)	0.112	149 (60)	0.875	66
		Metapop	0.007 (0.080)	0.014	152 (74)	0.883	94
30	70	LANWR	-0.022 (0.183)	0.978	6 (4)	0.340	58
		Wilacy	0.019 (0.135)	0.224	23 (11)	0.614	80
		Tamaulipas	0.046 (0.083)	0.000	194 (10)	0.919	–
		Metapop	0.042 (0.076)	0.000	212 (18)	0.928	–
60		LANWR	-0.009 (0.177)	0.816	10 (6)	0.528	77
		Wilacy	0.034 (0.125)	0.048	28 (10)	0.712	92
		Tamaulipas	0.039 (0.085)	0.000	194 (11)	0.919	–
		Metapop	0.037 (0.075)	0.000	222 (17)	0.933	–
30	50	LANWR	-0.011 (0.163)	0.874	10 (7)	0.473	69

		Wilacy	-0.014 (0.151)	0.772	12 (8)	0.559	74
		Tamaulipas	-0.024 (0.116)	0.320	63 (52)	0.795	69
		Metapop	-0.019 (0.099)	0.212	60 (53)	0.781	85
60		LANWR	0.001 (0.153)	0.546	11 (7)	0.598	86
		Wilacy	0.000 (0.139)	0.388	15 (10)	0.665	89
		Tamaulipas	-0.052 (0.140)	0.824	40 (42)	0.750	60
		Metapop	-0.019 (0.101)	0.178	27 (27)	0.746	93
30	60	LANWR	0.008 (0.157)	0.636	13 (8)	0.496	77
		Wilacy	0.010 (0.140)	0.342	21 (11)	0.601	80
		Tamaulipas	0.018 (0.090)	0.008	175 (36)	0.908	61
		Metapop	0.020 (0.079)	0.000	192 (43)	0.918	–
60		LANWR	0.026 (0.147)	0.272	17 (8)	0.636	89
		Wilacy	0.027 (0.127)	0.076	26 (10)	0.706	90
		Tamaulipas	0.005 (0.102)	0.130	155 (57)	0.881	71
		Metapop	0.016 (0.079)	0.002	172 (76)	0.905	93
30	70	LANWR	0.029 (0.150)	0.288	19 (8)	0.540	80
		Wilacy	0.034 (0.131)	0.102	28 (10)	0.642	83
		Tamaulipas	0.046 (0.090)	0.000	194 (12)	0.918	–
		Metapop	0.046 (0.079)	0.000	232 (21)	0.935	–
60		LANWR	0.048 (0.141)	0.088	21 (8)	0.656	91
		Wilacy	0.049 (0.125)	0.014	31 (10)	0.723	94
		Tamaulipas	0.038 (0.092)	0.002	192 (16)	0.916	64
		Metapop	0.043 (0.078)	0.000	241 (24)	0.940	–

- Longer periods of translocation can improve the viability of the south Texas ocelot populations, but at the expense of the Tamaulipas population: longer translocation programs actually *increase* the risk of extinction in the source population. The Tamaulipas population, despite the absence of appreciable mortality from vehicle impacts, is not large enough to demographically withstand the removal of four females bi-annually. This conclusion, however, is dependent on the assumption that the source population in Tamaulipas is just 200 individuals, distributed relatively close to the border with the United States. This assumption may be unrealistic; the source population may in fact be considerably larger – perhaps up to 1,000 individuals – if we base our population size estimate across the entire state. In this case, the removal of a relatively small number of ocelots will have a much smaller demographic impact. Care must be given in determining the total source population size before setting quantitative targets for translocation to smaller population in south Texas.

All in all, a carefully-designed translocation strategy appears to have considerable promise as a means of improving the viability of small remnant populations of ocelots on south Texas. Such a strategy, however, cannot be so aggressive as to compromise the demographic and genetic health of the source population in Tamaulipas. Vigilant monitoring of a program like this would be necessary, combined with improved transport protocols designed to minimize transit mortality, in order for long-term program success to be a realistic goal.

Future Directions for Additional Analysis

Impacts of habitat loss

Our models do not currently include a simulation of gradual erosion – or, for that matter, recovery – of ocelot habitat in south Texas and northern Tamaulipas. This is certainly a real possibility as the burgeoning human population expands into more and more urban areas. We need to better understand the nature of this expansion, and its specific impacts on both quantity and quality of ocelot habitat.

Impacts of disease

Preliminary discussions during baseline model development included the possibility of disease epidemics impacting ocelot populations in this area. While recognizing the potential risks, we were unable to parameterize a disease model with any real confidence at this time. Further discussions would be necessary to understand this process in greater detail.

Density-dependent survival

There was concern among workshop participants that we were not accurately modeling density dependent mortality in ocelot populations. It is quite likely that as population size decreases, rates of fecundity and survival may actually increase as competition for space, food and mates is reduced. This needs to be studied in more detail so that more accurate models can be developed.

Conclusions

We may conclude our preliminary analysis of south Texas/northern Tamaulipas ocelot population viability by returning to the original set of questions that provided the foundation for our study.

- *What is our best estimate of stochastic population dynamics of this species in its current range?*

  Based on our current understanding of the demographics of ocelot populations occupying south Texas and northern Tamaulipas, these populations, particularly those in south Texas, appear to be at a considerable risk of extinction through the action of intrinsic, stochastic fluctuations in demographic rates that are the hallmark of very small, isolated populations of wildlife. Moreover, this risk is directly tied to the activities of humans in the area, namely the construction and use of roads throughout ocelot habitat.

- *What are the primary factors that drive population growth dynamics of ocelots in south Texas and northern Tamaulipas?*

  Our preliminary set of PVA models discussed here show that ocelot growth dynamics is largely driven by adult female reproductive success, defined here as the proportion of adult females successfully producing a litter in a given year. Moreover, the additional levels of mortality brought about by vehicle collisions is a primary factor in determining the future growth dynamics of any given population subjected to such activity.

- *How vulnerable are small, fragmented populations of ocelots in south Texas and northern Tamaulipas to local extinction in the absence of demographic interaction with other populations?*

  Small populations of ocelots, for example, those numbering less than 100 individuals, have an elevated risk of extinction compared to their larger counterparts. When additional anthropogenic mortality is included in our analyses, even larger populations do not appear to be able to tolerate this kind of additional demographic stress.

- *What are the benefits to the ocelot of increasing range and connectivity in the landscape?*

  Because of the risk of extinction through isolation discussed above, range increase through habitat improvements may result in greater levels of ocelot population increase and, as a result, a reduced risk of extinction. This, of course, also depends on the success of mitigating human-mediated processes such as road mortality. As an alternative conservation measure, connecting small ocelot populations through the use of landscape corridors may provide an additional buffer against extinction risk. However, this strategy will meet with the greatest level of success when 1) individual subpopulations are increased in size in a way that approaches some level of viability in the absence of connectivity, 2) dispersal rates, whether natural or artificial, are sufficiently high to maintain a functioning metapopulation, and 3) anthropogenic sources of mortality are reduced to acceptable levels.

- *How successful might translocation be as a conservation management strategy for smaller populations of ocelots in south Texas?*

  Our models indicate that, based on our best understanding of the demographics of ocelots in this portion of their range, the input of a relatively small number of individuals can have a significant positive impact on the viability of endangered recipient populations. Preliminary analyses indicate that just one to two females injected into a population on a bi-annual basis may be enough to compensate for the destabilizing effect of stochastic demography operating on small populations.

- *How many animals could be removed from a given source population such as northern Tamaulipas for augmentation of smaller populations in south Texas at risk of extinction without negatively impacting the persistence of the source?*

  It appears that careful consideration must be given to the extent of removal of ocelots from the source population in Tamaulipas. Removing four subadult females every other year, comprising approximately 4% of the total female population, may put the population at some risk if translocations last longer than 40 to 50 years. A smaller number of individuals could no doubt be removed more easily, but the assumed transit mortality would lead to a greatly reduced demographic benefit to the recipient populations. These conclusions are strongly dependent on our assumptions of overall ocelot population size in the source regions of Tamaulipas; risks to this population may be reduced substantially if our estimates of total population size are increased.

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Appendix IV-I

Simulation Modeling and Population Viability Analysis

A model is any simplified representation of a real system. We use models in all aspects of our lives, in order to: (1) extract the important trends from complex processes, (2) permit comparison among systems, (3) facilitate analysis of causes of processes acting on the system, and (4) make predictions about the future. A complete description of a natural system, if it were possible, would often decrease our understanding relative to that provided by a good model, because there is "noise" in the system that is extraneous to the processes we wish to understand. For example, the typical representation of the growth of a wildlife population by an annual percent growth rate is a simplified mathematical model of the much more complex changes in population size. Representing population growth as an annual percent change assumes constant exponential growth, ignoring the irregular fluctuations as individuals are born or immigrate, and die or emigrate. For many purposes, such a simplified model of population growth is very useful, because it captures the essential information we might need regarding the average change in population size, and it allows us to make predictions about the future size of the population. A detailed description of the exact changes in numbers of individuals, while a true description of the population, would often be of much less value because the essential pattern would be obscured, and it would be difficult or impossible to make predictions about the future population size.

In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the standard ecological models of population change can cause population extinction, and therefore are often the primary focus of concern. In order to understand and predict the vulnerability of a wildlife population to extinction, we need to use a model which incorporates the processes which cause fluctuations in the population, as well as those which control the long-term trends in population size (Shaffer 1981). Many processes can cause fluctuations in population size: variation in the environment (such as weather, food supplies, and predation), genetic changes in the population (such as genetic drift, inbreeding, and response to natural selection), catastrophic effects (such as disease epidemics, floods, and droughts), decimation of the population or its habitats by humans, the chance results of the probabilistic events in the lives of individuals (sex determination, location of mates, breeding success, survival), and interactions among these factors (Gilpin and Soulé 1986).

Models of population dynamics which incorporate causes of fluctuations in population size in order to predict probabilities of extinction, and to help identify the processes which contribute to a population's vulnerability, are used in "Population Viability Analysis" (PVA) (Lacy 1993/4). For the purpose of predicting vulnerability to extinction, any and all population processes that impact population dynamics can be important. Much analysis of conservation issues is conducted by largely intuitive assessments by biologists with experience with the system. Assessments by experts can be quite valuable, and are often contrasted with "models" used to evaluate population vulnerability to extinction. Such a contrast is not valid, however, as *any* synthesis of facts and understanding of processes constitutes a model, even if it is a mental model within the mind of the expert and perhaps only vaguely specified to others (or even to the expert himself or herself).

A number of properties of the problem of assessing vulnerability of a population to extinction make it difficult to rely on mental or intuitive models. Numerous processes impact population dynamics, and many of the factors interact in complex ways. For example, increased fragmentation of habitat can make it more difficult to locate mates, can lead to greater mortality as individuals disperse greater distances across unsuitable habitat, and can lead to increased inbreeding which in turn can further reduce ability to attract mates and to survive. In addition, many of the processes impacting population dynamics are intrinsically probabilistic, with a random component. Sex determination, disease, predation, mate acquisition -- indeed, almost all events in the life of an individual -- are stochastic events, occurring with certain probabilities rather than with absolute certainty at any given time. The consequences of factors influencing population dynamics are often delayed for years or even generations. With a long-lived species, a population might persist for 20 to 40 years beyond the emergence of factors that ultimately cause extinction. Humans can synthesize mentally only a few factors at a time, most people have difficulty assessing probabilities intuitively, and it is difficult to consider delayed effects. Moreover, the data needed for models of population dynamics are often very uncertain. Optimal decision-making when data are uncertain is difficult, as it involves correct assessment of probabilities that the true values fall within certain ranges, adding yet another probabilistic or chance component to the evaluation of the situation.

The difficulty of incorporating multiple, interacting, probabilistic processes into a model that can utilize uncertain data has prevented (to date) development of analytical models (mathematical equations developed from theory) which encompass more than a small subset of the processes known to affect wildlife population dynamics. It is possible that the mental models of some biologists are sufficiently complex to predict accurately population vulnerabilities to extinction under a range of conditions, but it is not possible to assess objectively the precision of such intuitive assessments, and it is difficult to transfer that knowledge to others who need also to evaluate the situation. Computer simulation models have increasingly been used to assist in PVA. Although rarely as elegant as models framed in analytical equations, computer simulation models can be well suited for the complex task of evaluating risks of extinction. Simulation models can include as many factors that influence population dynamics as the modeler and the user of the model want to assess. Interactions between processes can be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programs, providing output that gives both the mean expected result and the range or distribution of possible outcomes. In theory, simulation programs can be used to build models of population dynamics that include all the knowledge of the system which is available to experts. In practice, the models will be simpler, because some factors are judged unlikely to be important, and because the persons who developed the model did not have access to the full array of expert knowledge.

Although computer simulation models can be complex and confusing, they are precisely defined and all the assumptions and algorithms can be examined. Therefore, the models are objective, testable, and open to challenge and improvement. PVA models allow use of all available data on the biology of the taxon, facilitate testing of the effects of unknown or uncertain data, and expedite the comparison of the likely results of various possible management options.

PVA models also have weaknesses and limitations. A model of the population dynamics does not define the goals for conservation planning. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modeling can be used. Because the models incorporate many factors, the number of possibilities to test can seem endless, and it can be difficult to determine which of the factors that were analyzed are most important to the population dynamics. PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models probably underestimate the threats facing the population. Finally, the models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programs as needed.

The *VORTEX* Population Viability Analysis Model

For the analyses presented here, the *VORTEX* computer software (Lacy 1993) for population viability analysis was used. *VORTEX* models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. *VORTEX* also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified to change linearly over time, to model losses or gains in the amount or quality of habitat. Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size.

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. During the simulation, *VORTEX* monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. *VORTEX* also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

VORTEX is an *individual-based* model. That is, *VORTEX* creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime. *VORTEX* keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modeled by determining for each animal in each year of the simulation whether any of the events occur. (See figure below.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

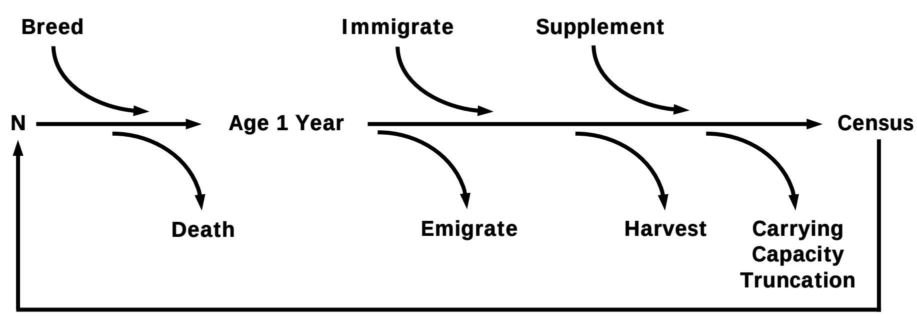
VORTEX requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because *VORTEX* requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalized life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on *VORTEX* is available in Lacy (2000) and Miller and Lacy (2003).

Dealing with Uncertainty

It is important to recognize that uncertainty regarding the biological parameters of a population and its consequent fate occurs at several levels and for independent reasons. Uncertainty can occur because the parameters have never been measured on the population. Uncertainty can occur because limited field data have yielded estimates with potentially large sampling error. Uncertainty can occur because independent studies have generated discordant estimates. Uncertainty can occur because environmental conditions or population status have been changing over time, and field surveys were conducted during periods which may not be

VORTEX Simulation Model Timeline



Events listed above the timeline increase N, while
events listed below the timeline decrease N.

representative of long-term averages. Uncertainty can occur because the environment will change in the future, so that measurements made in the past may not accurately predict future conditions.

Sensitivity testing is necessary to determine the extent to which uncertainty in input parameters results in uncertainty regarding the future fate of the pronghorn population. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population.

The above kinds of uncertainty should be distinguished from several more sources of uncertainty about the future of the population. Even if long-term average demographic rates are known with precision, variation over time caused by fluctuating environmental conditions will cause uncertainty in the fate of the population at any given time in the future. Such environmental variation should be incorporated into the model used to assess population dynamics, and will generate a range of possible outcomes (perhaps represented as a mean and standard deviation) from the model. In addition, most biological processes are inherently stochastic, having a random component. The stochastic or probabilistic nature of survival, sex determination, transmission of genes, acquisition of mates, reproduction, and other processes preclude exact determination of the future state of a population. Such demographic stochasticity should also be incorporated into a population model, because such variability both increases our uncertainty about the future and can also change the expected or mean outcome relative to that which would result if there were no such variation. Finally, there is "uncertainty" which represents the alternative actions or interventions which might be pursued as a management strategy. The likely effectiveness of such management options can be explored by testing alternative scenarios in the model of population dynamics, in much the same way that sensitivity testing is used to explore the effects of uncertain biological parameters.

Demographic Stochasticity

VORTEX models demographic stochasticity by determining the occurrence of probabilistic events such as reproduction, litter size, sex determination, and death with a pseudo-random number generator. For each life event, if the random value sampled from a specified distribution falls above the user-specified probability, the event is deemed to have occurred, thereby simulating a binomial process. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

The source code used to generate random numbers uniformly distributed between 0 and 1 was obtained from Maier (1991), based on the algorithm of Kirkpatrick and Stoll (1981). Random deviates from binomial distributions, with mean p and standard deviation s, are obtained by first determining the integral number of binomial trials, N, that would produce the value of s closest to the specified value, according to:

$$N = \frac{p(1-p)}{s^2}$$

N binomial trials are then simulated by sampling from the uniform 0-1 distribution to obtain the desired result, the frequency or proportion of successes. If the value of N determined for a desired binomial distribution is larger than 25, a normal approximation is used in place of the binomial distribution. This normal approximation must be truncated at 0 and at 1 to allow use in defining probabilities, although, with such large values of N, s is small relative to p and the truncation would be invoked only rarely. To avoid introducing bias with this truncation, the normal approximation to the binomial (when used) is truncated symmetrically around the mean. The algorithm for generating random numbers from a unit normal distribution follows Latour (1986).

Environmental Variation

VORTEX can model annual fluctuations in birth and death rates and in carrying capacity as might result from environmental variation. To model environmental variation, each demographic parameter is assigned a distribution with a mean and standard deviation that is specified by the user. Annual fluctuations in probabilities of reproduction and mortality are modeled as binomial distributions. Environmental variation in carrying capacity is modeled as a normal distribution. Environmental variation in demographic rates can be correlated among populations.

Catastrophes

Catastrophes are modeled in VORTEX as random events that occur with specified probabilities. A catastrophe will occur if a randomly generated number between zero and one is less than the probability of occurrence. Following a catastrophic event, the chances of survival and successful breeding for that simulated year are multiplied by severity factors. For example, forest fires might occur once in 50 years, on average, killing 25% of animals, and reducing breeding by survivors 50% for the year. Such a catastrophe would be modeled as a random event with 0.02 probability of occurrence each year, and severity factors of 0.75 for survival and 0.50 for reproduction. Catastrophes can be local (impacting populations independently), or regional (affecting sets of populations simultaneously).

Genetic Processes

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical neutral (non-selected) genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. Each offspring created during the simulation is randomly assigned one of the alleles from each parent. VORTEX monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. VORTEX also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

Inbreeding depression is modeled as a loss of viability of inbred animals during their first year. The severity of inbreeding depression is commonly measured by the number of "lethal equivalents" in a population (Morton et al. 1956). The number of lethal equivalents per diploid genome estimates the average number of lethal alleles per individual in the population if all deleterious effects of inbreeding were due entirely to recessive lethal alleles. A population in which inbreeding depression is one lethal equivalent per diploid genome may have one recessive lethal allele per individual, it may have two recessive alleles per individual, each of which confer a 50% decrease in survival, or it may have some other combination of recessive deleterious alleles which equate in effect with one lethal allele per individual.

VORTEX partitions the total effect of inbreeding (the total lethal equivalents) into an effect due to recessive lethal alleles and an effect due to loci at which there is heterozygote advantage (superior fitness of heterozygotes relative to all homozygote genotypes). To model the effects of lethal alleles, each founder starts with a unique recessive lethal allele (and a dominant non-lethal allele) at up to five modeled loci. By virtue of the deaths of individuals that are homozygous for lethal alleles, such alleles can be removed slowly by natural selection during the generations of a simulation. This diminishes the probability that inbred individuals in subsequent generations will be homozygous for a lethal allele.

Heterozygote advantage is modeled by specifying that juvenile survival is related to inbreeding

$$\ln(S) = A - BF$$

according to the logarithmic model: in which *S* is survival, *F* is the inbreeding coefficient, *A* is the logarithm of survival in the absence of inbreeding, and *B* is the portion of the lethal equivalents per haploid genome that is due to heterozygote advantage rather than to recessive lethal alleles. Unlike the situation with fully recessive deleterious alleles, natural selection does not remove deleterious alleles at loci in which the heterozygote has higher fitness than both homozygotes, because all alleles are deleterious when homozygous and beneficial when present in heterozygous combination with other alleles. Thus, under heterozygote advantage, the impact of inbreeding on survival does not diminish during repeated generations of inbreeding. Unfortunately, for relatively few species are data available to allow estimation of the effects of inbreeding, and the magnitude of these effects apparently varies considerably among species (Falconer 1981; Ralls et al. 1988; Lacy et al. 1992) and even among populations of the same species (Lacy et al. 1996). Even without detailed pedigree data from which to estimate the number of lethal equivalents in a population and the underlying nature of the genetic load (recessive alleles or heterozygote advantage), PVAs must make assumptions about the effects of inbreeding on the population being studied. If genetic effects are ignored, the PVA will overestimate the viability of small populations. In some cases, it might be considered appropriate to assume that an inadequately studied species would respond to inbreeding in accord with the median (3.14 lethal equivalents per diploid) reported in the survey by Ralls et al. (1988). In other cases, there might be reason to make more optimistic assumptions (perhaps the lower quartile, 0.90 lethal equivalents), or more pessimistic assumptions (perhaps the upper quartile, 5.62 lethal equivalents). In the few species in which inbreeding depression has been studied carefully, about half of the effects of inbreeding are due recessive lethal alleles and about half of the effects are due to heterozygote advantage or other genetic mechanisms that are not diminished by natural selection during generations of inbreeding, although the proportion of the total inbreeding effect can vary substantially among populations (Lacy and Ballou 1998).

A full explanation of the genetic mechanisms of inbreeding depression is beyond the scope of this manual, and interested readers are encouraged to refer to the references cited above.

VORTEX can model monogamous or polygamous mating systems. In a monogamous system, a relative scarcity of breeding males may limit reproduction by females. In polygamous or monogamous models, the user can specify the proportion of the adult males in the breeding pool.

Males are randomly reassigned to the breeding pool each year of the simulation, and all males in the breeding pool have an equal chance of siring offspring.

Deterministic Processes

VORTEX can incorporate several deterministic processes, in addition to mean age-specific birth and death rates. Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. Each animal in the population has an equal probability of being removed by this truncation. The carrying capacity can be specified to change over time, to model losses or gains in the amount or quality of habitat.

Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size. The default functional relationship between breeding and density allows entry of Allee effects (reduction in breeding at low density) and/or reduced breeding at high densities.

Populations can be supplemented or harvested for any number of years in each simulation. Harvest may be culling or removal of animals for translocation to another (unmodeled) population. The numbers of additions and removals are specified according to the age and sex of animals.

Migration Among Populations

VORTEX can model up to 50 populations, with possibly distinct population parameters. Each pairwise migration rate is specified as the probability of an individual moving from one population to another. Migration among populations can be restricted to one sex and/or a limited age cohort. Emigration from a population can be restricted to occur only when the number of animals in the population exceeds a specified proportion of the carrying capacity. Dispersal mortality can be specified as a probability of death for any migrating animal, which is in addition to age-sex specific mortality. Because of between-population migration and managed supplementation, populations can be recolonized. *VORTEX* tracks the dynamics of local extinctions and recolonizations through the simulation.

Output

VORTEX outputs: **(1)** probability of extinction at specified intervals (e.g., every 10 years during a 100 year simulation), **(2)** median time to extinction, if the population went extinct in at least 50% of the simulations, **(3)** mean time to extinction of those simulated populations that became extinct, and **(4)** mean size of, and genetic variation within, extant populations.

Standard deviations across simulations and standard errors of the mean are reported for population size and the measures of genetic variation. Under the assumption that extinction of independently replicated populations is a binomial process, the standard error of the probability

$$\mathrm{SE}(p) = \sqrt{\frac{p(1-p)}{n}}$$

of extinction is reported by *VORTEX* as: in which the frequency of extinction was *p* over *n* simulated populations. Demographic and genetic statistics are calculated and reported for each subpopulation and for the metapopulation.

Sequence of Program Flow

(1) The seed for the random number generator is initialized with the number of seconds elapsed since the beginning of the 20th century.

(2) The user is prompted for an output file name, duration of the simulation, number of iterations, the size below which a population is considered extinct, and a large number of population parameters.

(3) The maximum allowable population size (necessary for preventing memory overflow) is

$$K_{\max} = (K + 3s)(1 + L)$$

calculated as: in which *K* is the maximum carrying capacity (carrying capacity can be specified to change during a simulation, so the maximum carrying capacity can be greater than the initial carrying capacity), *s* is the annual environmental variation in the carrying capacity expressed as a standard deviation, and *L* is the specified maximum litter size.

(4) Memory is allocated for data arrays. If insufficient memory is available for data arrays then N_{max} is adjusted downward to the size that can be accommodated within the available memory and a warning message is given. In this case it is possible that the analysis may have to be terminated because the simulated population exceeds N_{max}. Because N_{max} is often several-fold greater than the likely maximum population size in a simulation, a warning that it has been adjusted downward because of limiting memory often will not hamper the analyses.

(5) The deterministic growth rate of the population is calculated from mean birth and death rates that have been entered. Algorithms follow cohort life-table analyses (Ricklefs 1979). Generation time and the expected stable age distribution are also calculated. Life-table calculations assume constant birth and death rates, no limitation by carrying capacity, no limitation of mates, no loss of fitness due to inbreeding depression, and that the population is at the stable age distribution. The effects of catastrophes are incorporated into the life table analysis by using birth and death rates that are weighted averages of the values in years with and without catastrophes, weighted by the probability of a catastrophe occurring or not occurring.

(6) Iterative simulation of the population proceeds via steps 7 through 26 below.

(7) The starting population is assigned an age and sex structure. The user can specify the exact age-sex structure of the starting population, or can specify an initial population size and request that the population be distributed according to the stable age distribution calculated from the life table. Individuals in the starting population are assumed to be unrelated. Thus, inbreeding can occur only in second and later generations.

(8) Two unique alleles at a hypothetical neutral genetic locus are assigned to each individual in the starting population and to each individual supplemented to the population during the simulation. *VORTEX* therefore uses an infinite alleles model of genetic variation. The subsequent fate of genetic variation is tracked by reporting the number of extant neutral alleles each year, the expected heterozygosity or gene diversity, and the observed

$$H_e = 1 - \sum \left(p_i^2\right)$$

heterozygosity. The expected heterozygosity, derived from the Hardy-Weinberg equilibrium, is given byin which p_i is the frequency of allele *i* in the population. The observed heterozygosity is simply the proportion of the individuals in the simulated population that are heterozygous. Because of the starting assumption of two unique alleles per founder, the initial population has an observed heterozygosity of 1.0 at the hypothetical locus and only inbred animals can become homozygous. Proportional loss of heterozygosity through random genetic drift is independent of the initial heterozygosity and allele frequencies of a population (Crow and Kimura 1970), so the expected heterozygosity remaining in a simulated population is a useful metric of genetic decay for comparison across scenarios and populations. The mean observed heterozygosity reported by *VORTEX* is the mean inbreeding coefficient of the population.

(9) For each of the10 alleles at five non-neutral loci that are used to model inbreeding depression, each founder is assigned a unique lethal allele with probability equal to 0.1 x the mean number of lethal alleles per individual.

(10) Years are iterated via steps 11 through 25 below.

(11) The probabilities of females producing each possible size litter are adjusted to account for density dependence of reproduction (if any).

(12) Birth rate, survival rates, and carrying capacity for the year are adjusted to model environmental variation. Environmental variation is assumed to follow binomial distributions for birth and death rates and a normal distribution for carrying capacity, with mean rates and standard deviations specified by the user. At the outset of each year a random number is drawn from the specified binomial distribution to determine the percent of females producing litters. The distribution of litter sizes among those females that do breed is maintained constant. Another random number is drawn from a specified binomial distribution to model the environmental variation in mortality rates. If environmental variations in reproduction and mortality are chosen to be correlated, the random number used to specify mortality rates for the year is chosen to be the same percentile of its binomial distribution as was the number used to specify reproductive rate. Otherwise, a new random number is drawn to specify the deviation of age- and sex-specific mortality rates from their means. Environmental variation across years in mortality rates is always forced to be correlated among age and sex classes.

The carrying capacity (*K*) for the year is determined by first increasing or decreasing the carrying capacity at year 1 by an amount specified by the user to account for changes over time. Environmental variation in K is then imposed by drawing a random number from a normal distribution with the specified values for mean and standard deviation.

(13) Birth rates and survival rates for the year are adjusted to model any catastrophes determined to have occurred in that year.

(14) Breeding males are selected for the year. A male of breeding age is placed into the pool of potential breeders for that year if a random number drawn for that male is less than the proportion of adult males specified to be breeding. Breeding males are selected independently each year; there is no long-term tenure of breeding males and no long-term pair bonds.

(15) For each female of breeding age, a mate is drawn at random from the pool of breeding males for that year. If the user specifies that the breeding system is monogamous, then each male can only be paired with a single female each year. Males are paired only with those females which have already been selected for breeding that year. Thus, males will not be the limiting sex unless there are insufficient males to pair with the successfully breeding females.

If the breeding system is polygynous, then a male may be selected as the mate for several females. The degree of polygyny is determined by the proportion of males in the pool of potential breeders each year.

The size of the litter produced by that pair is determined by comparing the probabilities of each potential litter size (including litter size of 0, no breeding) to a randomly drawn number. The offspring are produced and assigned a sex by comparison of a random number to the specified birth sex ratio. Offspring are assigned, at random, one allele at the hypothetical genetic locus from each parent.

(16) The genetic kinship of each new offspring to each other living animal in the population is

$$f_{AB} = 0.5(f_{MB} + f_{PB})$$

determined. The kinship between new animal A, and another existing animal, B, is in which f_{ij} is the kinship between animals i and j, M is the mother of A, and P is the father of A. The inbreeding coefficient of each animal is equal to the kinship between its parents, $F = f_{MP}$, and the kinship of an animal to itself is $f_A = 0.5(1 + F)$. (See Ballou 1983 for a detailed description of this method for calculating inbreeding coefficients.)

(17) The survival of each animal is determined by comparing a random number to the survival probability for that animal. In the absence of inbreeding depression, the survival probability is given by the age and sex-specific survival rate for that year. If a newborn individual is homozygous for a lethal allele, it is killed. Otherwise, the survival probability for

$$e^{-b(1-\Pr[Lethals])F}$$

individuals in their first year is multiplied by in which b is the number of lethal equivalents per haploid genome, and Pr[*Lethals*] is the proportion of this inbreeding effect due to lethal alleles.

(18) The age of each animal is incremented by 1.

(19) If more than one population is being modeled, migration among populations occurs stochastically with specified probabilities.

(20) If population harvest is to occur that year, the number of harvested individuals of each age and sex class are chosen at random from those available and removed. If the number to be removed does not exist for an age-sex class, *VORTEX* continues but reports that harvest was incomplete.

(21) Dead animals are removed from the computer memory to make space for future generations.

(22) If population supplementation is to occur in a particular year, new individuals of the specified age-class are created. Each immigrant is assumed to be genetically unrelated to all other individuals in the population, and it carries the number of lethal alleles that was specified for the starting population.

(23) The population growth rate is calculated as the ratio of the population size in the current year to the previous year.

(24) If the population size (N) exceeds the carrying capacity (K) for that year, additional mortality is imposed across all age and sex classes. The probability of each animal dying during this carrying capacity truncation is set to $(N - K)/N$, so that the expected population size after the additional mortality is K.

(25) Summary statistics on population size and genetic variation are tallied and reported.

(26) Final population size and genetic variation are determined for the simulation.

(27) Summary statistics on population size, genetic variation, probability of extinction, and mean population growth rate are calculated across iterations and output.

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Appendix V – Programs and Resources to Assist Landowners and Partners in Implementing the Ocelot Recovery Plan.

GENERAL INFORMATION FOR OCELOTS

Websites

US Fish & Wildlife Service (USFWS):
http://ecos.fws.gov/species_profile/SpeciesProfile?spcode=A084.

Laguna Atascosa National Wildlife Refuge:
http://www.fws.gov/southwest/refuges/texas/laguna.html.

Lower Rio Grande Valley National Wildlife Refuge:
http://www.fws.gov/southwest/refuges/texas/lrgv.html.

Santa Ana National Wildlife Refuge:
http://www.fws.gov/southwest/refuges/texas/santaana.html.

Nature Serve:
http://www.natureserve.org/explorer/servlet/Natureserve?searchName=Leopardus+pardalis

Bordercats Working Group:
This organization provides information on wild cat species that occur along the U.S. – Mexico border: http://www.cas.usf.edu/~grigione/BWG/Index.html.

Dallas Zoo Conservation Education and Science Department:
This organization has developed an interactive bilingual web-based program, "The Ocelot Experience," at http://www.dallaszooed.com. The program targets 4th through 6th graders using Spanish and English to help students learn more about the ocelot and how to protect it.

STATE PROGRAMS

<u>Arizona</u>

Arizona Game and Fish Department (AZGFD): http://www.gf.state.az.us/.
Heritage Grants Program
AZGFD's IIAPM (Identification, Inventory, Acquisition, Protection and Management of Sensitive Habitats) sub-program provides funds through a competitive process for projects that preserve and enhance Arizona's natural biological diversity. The funding focus is directed toward species and habitat objectives that will give the greatest return for the Heritage funds invested. Contact the Heritage Grants Coordinator (602/789-3530) or visit the website at: http://www.gf.state.az.us/w_c/heritage_apply.shtml.

Landowner Incentive Program (LIP)
This program provides funds for on-the-ground activities that enhance habitats or provide other conservation benefits for "at risk" species on private lands. The LIP is a grant program establishing a partnership among Federal/state governments and private landowners. At the Federal level, administrative oversight will be provided by the USFWS. The USFWS will award grants to states for programs that enhance, protect, and/or restore habitats that benefit federally-listed species, proposed or candidate species, or other species at risk on private lands. The state's role in the implementation of LIP is to provide technical and financial assistance to private landowners for projects that meet the aforementioned criteria. The private landowner role is to provide the habitat necessary to accomplish the objectives of LIP. Additionally, the USFWS requires a 25% non-Federal match, cash or in-kind contribution, to be eligible for these funds. In Arizona, contact: Landowner Relations Program Manager, 2221 W. Greenway Rd., Phoenix, AZ 85023-4312, AZGFD's Regional Habitat Program in Tucson (520/628-5376), or visit the website at: http://www.gf.state.az.us/outdoor_recreation/landowner_lip.shtml. Nationally, see the LIP website at: http://federalasst.fws.gov/lip/lip.html.

State Wildlife Grants Program via Comprehensive Wildlife Conservation Program (CWCP)
This nationwide program is designed to provide financial assistance in response to proposals to research, monitor, or implement conservation measures for threatened or endangered species. For Arizona, information is available at the website: http://www.gf.state.az.us/w_c/cwcs.shtml.

Stewardship Program
This program provides technical management assistance, including use of heavy equipment, materials, and labor, or reimbursement of materials and labor, to enhance wildlife habitat and populations. Projects can occur on private or public lands. Contact AZGFD's Regional Habitat Programs in Tucson (520/628-5376).

Arizona Department of Water Resources

The Arizona Water Protection Fund Commission
All applicants will be required to demonstrate the direct benefit(s) to rivers, streams, and/or riparian habits in their proposals. Complete information regarding the grant cycle, including workshop times, is posted on the Arizona Water Protection Fund website: http://www.awpf.state.az.us.

Texas

Texas Parks and Wildlife Department (TPWD): http://www.tpwd.state.tx.us/; or see: http://www.tpwd.state.tx.us/huntwild/wild/species/endang/index.phtml (then click on grants along the top margin of the page headings).

Landowner Incentive Program (LIP)
http://www.tpwd.state.tx.us/landwater/land/private/lip/. This program encourages creative and effective projects for conserving rare species and provides financial incentives. As most rare species inhabit privately owned and managed lands in Texas, see the website to determine which species are found locally (http://www.tpwd.state.tx.us/landwater/land/habitats/). Funds can be

used for projects that enhance, restore, or protect habitat. For information, contact: Cecily Warren, Texas Parks & Wildlife Department, 4200 Smith School Road, Austin, TX 78744 (512/389-4799). On the web visit: http://www.tpwd.state.tx.us/landwater/land/private/lip/ or: http://www.tpwd.state.tx.us/business/grants/wildlife/.

Private Lands and Habitat Management Program
This program provides advice and information specifically tailored to each property and wildlife assemblage therein. The goals are to enhance habitat quality and property values, and conserve wildlife. Devising a management plan specific to each property involves a meeting with a biologist and then the formulation of recommendations that will incorporate the landowner's goals, management of wildlife as a renewable natural resource, and increased ecological diversity. For more information, visit the website at: http://www.tpwd.state.tx.us/landwater/land/private/description/.

State Wildlife Grants Program via Comprehensive Wildlife Conservation Program (CWCP)
This nationwide program, funded by the USFWS, is designed to provide financial assistance in response to proposals to research, monitor, or implement conservation measures for threatened or endangered species. For Texas, a copy of the program may be reviewed at: http://www.tpwd.state.tx.us/business/grants/wildlife/cwcs/.

Transportation Programs

National Scenic Byways Grants Program
This program provides funds for areas located along a National Scenic Byway, All-American Road, or State Scenic Byway. Corridor management plans, and natural resource protection through acquiring scenic easements are among the eligible projects. See the website at: http://www.bywaysonline.org/grants/.

Transportation Enhancement Program
This program funds a wide range of projects, including those that reduce vehicular collisions with wildlife and maintain habitat connectivity. Funding covers the construction of wildlife underpasses, bridges, or fences. Projects must be financially supported by Federal, state, Tribal, or local governments to receive the reimbursements issued by this program. For Texas, more information is available at the website at: http://www.dot.state.tx.us/des/step/introduction.htm. In Arizona, see the website at: http://www.dot.state.az.us/Highways/EEG/enhancement_scenic_roads/enhancement/index.asp.

FEDERAL PROGRAMS

U.S. Fish and Wildlife Service

Conservation Banks
Conservation Banks are lands that are permanently protected and managed as mitigation for the loss elsewhere of listed species and their habitats. Driven by free market demands, Conservation Banks enable landowners with suitable, conserved lands to make money selling mitigation

credits to other landowners who need to mitigate their land development impacts on listed species. For more information, see: www.fws.gov/endangered/landowner/index.html.

Cooperative Endangered Species Conservation Fund

These grants, authorized by section 6 of the Endangered Species Act, enable states to work with private landowners, conservation groups, and other agencies with conservation efforts and acquire and protect habitat for threatened and endangered species. For information, see: http://www.fws.gov/endangered/grants/section6/index.html.

Endangered Species Act "Traditional" Section 6 Conservation Grants

These are funds provided to AZGFD and TPWD to implement recovery actions, survey and monitor sensitive species, perform candidate assessments, and other related actions. The funds may be used on private, state, or Federal lands. In Arizona, contact the USFWS Traditional Section 6 Coordinator (602/242-0210). Contact the AZGFD Non-game Branch in Phoenix for information concerning section 6 projects (602/789-3555). In Texas, see the website at: http://www.fws.gov/endangered/grants/index.html.

Endangered Species Act "Non-traditional" Section 6 Funds

Recent initiatives have provided additional Federal funding ($70.5 million in September 2005) to AZGFD and TPWD for habitat conservation planning and land acquisitions. For information on these grants, contact: AZGFD Habitat Branch (602/789-3602), TPWD (512/912-7018). In Washington, DC, Michael Gale (202/219-8104) or Don Morgan (703/358-2061) may be contacted. Information is also available through the USFWS website, at: http://www.fws.gov/endangered/grants/section6/index.html.
Texas has its own information on the web at:
http://www.tpwd.state.tx.us/business/grants/wildlife/section_6/.

Habitat Conservation Planning Assistance Grants

These grants fund the development of Habitat Conservation Plans (HCPs) through support of baseline surveys and inventories, document preparation, outreach, and similar planning activities.

HCP Land Acquisition Grants

These funds may be used to acquire land associated with approved HCPs. Grants do not fund the mitigation required by an HCP permittee, but rather support conservation actions by the state, local governments, or other entities that complement mitigation.

Recovery Land Acquisitions Grants

These funds may be used for acquisition of habitat to secure long-term protection for a listed species. Land acquisition projects that address high priority recovery plan actions are most competitive.

Federal Aid in Wildlife Restoration

This program, based on the Federal Aid in Wildlife Restoration Act, popularly known as the Pittman-Robertson Act, provides funding for the selection, restoration, rehabilitation, and improvement of wildlife habitat, wildlife management research, and the distribution of

information produced by the projects. The program is a cost-reimbursement program, where the state covers the full amount of an approved project then applies for reimbursement through Federal Aid for up to 75% of project expenses. The state must provide at least 25% of the project costs from a non-Federal source.
Website: http://federalaid.fws.gov/grants/grantinf.html.

Partners for Fish and Wildlife Program
This program provides technical and financial assistance to landowners who want to improve fish and wildlife habitat on their property. The program is open to private individuals, Tribes, counties, and state governments. Contact the Partners Program Coordinator in Arlington, TX (281/277-1100) or Phoenix, AZ (602/670-6150). Information on funding restoration projects on private land is available at the website: http://www.fws.gov/ifw2es/Partners/. Also see the websites: http://www.fws.gov/arlingtontexas/pfw.htm in Texas and in Arizona: http://www:fws.gov/arizonaes/ and http://www.fws.gov/partners/pdfs/AZ-needs.pdf.

Private Stewardship Grant Program
This program provides funds and other assistance to individuals and groups engaged in local, private, and voluntary conservation efforts that benefit federally-listed, proposed, or candidate species, or other at risk species. Contact the USFWS, Arlington, Texas (817/277-1100). More information about the program is available on the USFWS website, at: http://www.fws.gov/endangered/grants/private_stewardship/index.html.

State Wildlife Grants
The State Wildlife Grants Program provides Federal funding to every state and territory to support cost effective conservation aimed at keeping wildlife from becoming endangered. This program continues the long history of cooperation between the Federal government and the states for managing and conserving wildlife. A two-thirds or greater non-Federal match is required. State Wildlife Grants are administered by AZGFD and TPWD. See information about the program at www.teaming.com.

Tribal Landowner Incentive Program
This is a grants program for actions and activities that protect and restore habitats that benefit federally-listed, proposed, or candidate species, or other at-risk species on Tribal lands. The program is available to federally-recognized Tribes. Tribal landowner incentive program funds can be used for environmental review, habitat evaluation, permit review, and other compliance so long as those activities are directly related to the Tribal landowner incentive program project. A minimum of 25% non-Federal matching funds is required. Contact the USFWS, Albuquerque, New Mexico (505/248-6810) for additional information. Also see the grant application kit at: http://grants.fws.gov.

Tribal Wildlife Grants Program
This program is designed to develop and implement programs for the benefit of wildlife and their habitat, including species that are not hunted or fished. Participation is limited to federally-recognized Indian Tribal governments. There is no matching requirement; however, the USFWS will consider matching funds as an indication of Tribal commitment to the program and will encourage partnerships. Matching and cost sharing requirements are discussed in 43 CFR Part

12, Section 12.64. Application procedures are spelled out in the "Tribal Wildlife Grant Application Kit" available electronically at http://grants.fws.gov/tribal.html.

Environmental Protection Agency (EPA)

The EPA's website of "Catalog of Federal Funding Sources for Watershed Protection" contains a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed protection projects. Searches can be limited to those for which "conservation districts" are eligible. See http://cfpub.epa.gov/fedfund/.

Natural Resource Conservation Service (NRCS)

<u>Conservation Innovation Grants</u>
As a part of the Environmental Quality Incentives Program (EQIP), Conservation Innovation Grants provide 50% of the cost to stimulate the development and adoption of innovative conservation approaches and technologies. National website: http://www.nrcs.usda.gov/programs/cig/. Contact Gus Jordan (202/690-2621).

<u>Conservation Reserve Program</u>
This is a voluntary program that offers annual rental payments and cost-share assistance to establish long-term resource conservation. The program provides up to 50% of participant costs to establish target management practices on private lands, and could be used to help establish riparian buffers and cienegas on private lands. In Arizona, contact NRCS, Tucson (520/670-6602). In Texas, visit the website at: http://www.tpwd.state.tx.us/landwater/land/private/farmbill/crp/. For national programs, see the website at: http://www.fsa.usda.gov/dafp/cepd/crp.htm.

<u>Grassland Reserve Program</u>
This program serves to restore, enhance, and protect grasslands through conservation easements, while maintaining existing grazing practices. National website: http://www.nrcs.usda.gov/programs/GRP/. In Arizona, contact Jeff Schmidt (602/280-8818); website: http://www.az.nrcs.usda.gov/programs/grp/grp2005.html. In Texas, contact Chuck Kowaleski (254/742-9874); website: http://www.tx.nrcs.usda.gov/programs/GRP/index.html.

<u>Resource Conservation and Development Program (RC&D)</u>
This program was established to accelerate conservation and community development in rural areas. Up to 25% of the cost is provided for the protection of fish and wildlife habitats. The program also funds (up to 25%) the protection of farmland in certain areas. See the website at: http://www.nrcs.usda.gov/Programs/rcd/.

<u>Wetlands Reserve Program</u>
This program can be used as cost-share (NRCS pays up to 75%) for restoration of privately-owned wetlands or former wetlands on rangelands or farmlands. In Arizona, contact NRCS, Tucson (520/670-6602). In Texas, visit NRCS on the web at: http://www.tx.nrcs.usda.gov/programs/wrp.html.

Wildlife Habitat Incentives Program (WHIP)
This program provides technical assistance and cost-share (up to 75%) to help establish and improve fish and wildlife habitat, primarily on private lands. In Arizona, contact NRCS, Tucson (520/670-6602, ext. 226). In Texas, visit the website at: http://www.nrcs.usda.gov/Programs/whip/.

U.S. Forest Service Programs

Bring Back the Natives
This initiative is a national effort by the Bureau of Land Management and Forest Service in cooperation with the National Fish and Wildlife Foundation to restore health of entire riverine and aquatic systems and their native species. In turn, national, state, and local partners make their own matching contributions to accomplish improved habitat and water quality. Three programs are available through the Forest Service: 1) *Rise to the Future* is a program to enhance fisheries and aquatic resources, 2) *Every Species Counts* conserves sensitive flora and fauna, and helps recover endangered species, and 3) *Get Wild* targets protection and improvement of riparian and wetland habitats and associated species. Forest Service funds must be matched with labor and materials. Contact the Coronado National Forest, Sierra Vista Ranger District, 5990 S. Highway 92, Hereford, Arizona, 85615 (520/378-0311). Bring Back the Natives funds can also be obtained through the National Fish and Wildlife Foundation (see below).

National Association of Conservation Districts

Five-Star Restoration Challenge Grants to Fund Habitat Restoration Projects
The National Association of Counties, the National Fish and Wildlife Foundation, and the Wildlife Habitat Council, in cooperation with the U.S. Environmental Protection Agency, the Community-Based Restoration Program within National Oceanic and Atmospheric Administration's Fisheries Program, and other sponsors of this grant. The program provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach, and training activities. Projects must involve diverse partnerships of, ideally, five organizations that contribute funding, land, technical assistance, workforce support, and/or other in-kind services. For further information, see the National Fish and Wildlife Foundation website at: http://nfwf.org/programs/5star-rfp.htm.

PRIVATE ORGANIZATIONS AND FOUNDATIONS

Many private grants and foundations could provide funding and other resources for recovery action implementation, both national and international. An annual directory, entitled "Environmental Grantmaking Foundations" contains information about 800 foundations. It is available from the Resources for Global Sustainability, Inc., P.O. Box 3665, Cary, NC 27519-3665 (800/724-1857, rgs@environmentalgrants.com). A website (Red Lodge Clearinghouse Funding Search – http://www.redlodgeclearinghouse.org/resources/search.asp) also provides an abundance of information on funding opportunities. Several examples of private grant and foundation programs are listed below:

Environmental Defense (ED)

The Landowner Conservation Assistance Program (LCAP) works with private landowners in locations that may be used by the ocelot to provide additional habitat or enhance existing habitat. Given that the removal of over 95% of native thornscrub habitat from the Lower Rio Grande Valley and northeastern Mexico is the primary cause for ocelot decline, incentives for restoring and protecting habitat within the ocelot's potential range are provided through the LCAP program. Contact Environmental Defense at kchapman@ed.org or by phone (956/466-4655) in Brownsville, Texas. For general information about Environmental Defense and its focus on the ocelot, visit the website at: http://www.environmentaldefense.org/article.cfm?contentID=5110&campaign=.

The Conservation Reserve Program (CRP) is a collaborative effort among Environmental Defense, the Natural Resource Conservation Service, and the Farm Services Agency to create and implement actions that provide shared costs to landowners for establishing Tamaulipan thornscrub on their land. Contact Environmental Defense at kchapman@ed.org or by phone (956/466-4655).

In 2003, the Ocelot Nation Program was formed to assist the ocelot spanning the U.S./Mexican border. Environmental Defense (ED) has teamed up with both The Nature Conservancy and Pronatura Noreste, a Mexican conservation group, to try to create a 130-mile long, cross-border corridor to let the Texas cats breed with their Mexican counterparts. Working with the USFWS, ED has begun restoration projects with Texas ranchers in Willacy and Cameron Counties. Because young cats are capable of swimming the Rio Grande or the Brownsville ship channel in search of a home range and breeding partners, ED is also working with Mexican landowners to establish protection for the ocelot. U.S. landowners can consider a suite of tools developed by Environmental Defense. In addition to establishing Safe Harbor Agreements, which guarantee that habitat improvements won't result in added government regulation, ED also helps landowners develop new forms of income like nature tourism.

In Mexico, the situation is more complicated. Pronatura has instituted the country's first conservation easements, but faces difficulties in defining boundaries. Together, incentives are being explored for landowners to help ocelots, particularly along the Gulf Coast, where important potential ocelot habitat is becoming increasingly impacted by human land use patterns.

Friends of the Laguna Atascosa National Wildlife Refuge

This is a non-profit, local group that sponsors the annual Ocelot Festival and the "adopt an ocelot" program. The Friends group raises money and then enhances these funds by partnering with other groups and matching funds for the purchase and restoration of potential ocelot habitat. Laguna Atascosa National Wildlife Refuge, P.O. Box 450, Rio Hondo, TX 78583; telephone: 956/748-3607.

National Fish and Wildlife Foundation Grants

Grants from the National Fish and Wildlife Foundation fund projects in two forms: one is through matching grants to projects that conserve and restore wildlife and plants, generally involving government, educational institutions, or non-profit organizations (http://www.nfwf.org/programs.cfm); the other is through the Special Grant Programs which are a collection of at least 42 different funds (http://www.nfwf.org/grant_apply.cfm). Of these, the following 12 funds could support ocelot projects: Acres for America, Bring Back the Natives, Budweiser Conservation Scholarship Program, Coastal Counties Restoration Initiative, Five-Star Restoration Matching Grants Program, Hurricane Wildlife Relief Fund, National Wildlife Refuge Friends Group Grant Program, Native Plant Conservation Initiative, Conservation on Private Lands, Nature of Learning, Pulling Together Initiative, State Comprehensive Wildlife Conservation Support Program. All of these programs have specific information and contacts available on the web page given above.

Feline Conservation Federation

The Feline Conservation Federation has previously worked with the Dallas Zoo to fund wild felid surveys in Mexico. See the website: http://www.thefcf.com/.

National Wildlife Federation

The National Wildlife Federation has funded ocelot conservation work in the past (see: http://www.nwf.org/wildlife/grants/grantrecipients2002.cfm). Grants from the National Wildlife Federation periodically are available based on current funding. See the website: http://www.nwf.org/wildlife/grants/ for updates and requirements.

The Nature Conservancy (TNC)

The Nature Conservancy is known for its partnerships in conservation efforts and its purchasing of property to preserve habitat. At present, TNC is supporting international and national conservation efforts that will enhance ocelot habitat (see: http://www.nature.org/pressroom/press/press326.html) and is partnering with Pronatura Noreste of Mexico, Environmental Defense, and the USFWS to manage for ocelots along the Mexico-US border. See the website at: http://www.nature.org/initiatives/programs/ to obtain information about supported programs. For private property conservation and easement purchase by TNC, see the website at: http://www.nature.org/aboutus/howwework/conservationmethods/privatelands/. Other forms of conservation projects that may be supported are Debt-for-Nature Swaps (usually international), Conservation Trust Funds, Payments for Ecosystem Services, and Resource Extraction Fees, and Public Finance Campaigns. For more information, see: http://www.nature.org/aboutus/howwework/conservationmethods/conservationfunding/.

Toyota TAPESTRY Grants for Teachers

Fifty teachers will be awarded as much as $10,000 and another 20 will receive grants up to $2,500 for innovative science projects in 1 of 3 categories, including environmental science. Projects should demonstrate creativity, model a novel way of presenting science and be implemented in the school district over a one-year period. For general information, tips on applying, or examples of winning projects, visit http://www.nsta.org/programs/tapestry. To download the application or request entry materials, go to http://www.nsta.org/programs/tapestry/howtoapply.asp. For more information, e-mail tapestry@nsta.org.

FINAL NOTE:

Voluntary measures can be taken by landowners that generally enhance the likelihood of obtaining financial assistance from the sources given above. For endangered species, such as the ocelot, these measures include participation in USFWS programs, such as Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs). On the web, please see: http://www.fws.gov/endangered/landowner/index.html for landowner information.

Habitat Conservation Plans are crafted when a landowner has a proposed project that may affect a threatened or endangered species currently existing on non-Federal lands. Together with the USFWS, the landowner develops an HCP that includes an assessment of likely impacts to the species from the proposed project, the steps that will be taken to minimize and mitigate those impacts, and the funding available to implement the steps. If the HCP meets specific criteria, the USFWS issues an incidental take permit that allows the landowner to incidentally take listed species in the course of proceeding with development or other activities. Programmatic HCPs, that cover an entire county or region, may also be devised or may already exist in an area and willing landowners may be included under a Certificate of Inclusion. Habitat Conservation Plans allow for economic development in conjunction with endangered species conservation. For more information, on the web refer to: http://www.fws.gov/endangered/hcp/index.html.

Safe Harbor Agreements are designed to help participating landowners conserve threatened and endangered species voluntarily. This agreement is made in exchange for legal assurances from the USFWS that new restrictions stemming from the Endangered Species Act will not be placed on the use of their land as a result of their voluntarily providing a net conservation benefit that may attract a threatened or endangered species in the future. Please see: http://www.fws.gov/endangered/pubs/Safe%20Harbor/SafeHarbor.pdf and http://www.fws.gov/endangered/sha/.

Appendix VI – Comments on the Draft Ocelot Recovery Plan and Responses to Comments (To be prepared after public review of the draft plan)