**NASA DEVELOP National Program**



NASA Marshall Space Flight Center

*Summer 2015*

Texas and Arizona Ecological Forecasting

Utilizing NASA Earth Observations to Monitor and Manage Ocelot Habitat Loss

 **Technical Report**

Rough Draft – June 25, 2015

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# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

Princeton Maximum Entropy Model, Endangered Species, Land Cover Classification, Normalized Difference in Vegetation, Landsat, Time Series, Habitat, Ocelot

# II. Introduction

The ocelot (*Leopardus pardalis*) is severely endangered in the United States with less than a hundred individuals remaining in the wild (Zerinskas & Pollio 2013). Some estimates predict as few as fifty extant cats (Booth-Binczik et al. 2013). The historical ocelot range extended from Argentina (Caso et al. 2008) into Arizona, Texas, Louisiana, and Arkansas (Connolly 2009). Ocelots have since been extirpated from most of its range in the United States, largely due to habitat loss and hunting by humans for their pelts and to reduce perceived livestock conflicts (Connolly 2009). Congress added the ocelot to the U.S. Endangered Species Act (ESA) in 1981 (Zerinskas & Pollio 2013). The largest remaining populations exist in the Laguna Atascosa National Wildlife Refuge (LANWR) and in private ranches, both in southern Texas (Haines et al. 2005a). In Arizona, researchers have documented the presence of ocelots, but population numbers are not well known (Avila-Villegas & Lamberton-Moreno 2012).

The ocelot is an elusive nocturnal felid (Laack et al. 2005; Janecka et al. 2014). Throughout most of the ocelot’s Neotropical range, ocelots occupy a spectrum of habitats, including grasslands, tropical forests, wetlands, and vegetated deserts (Trolle & Kery 2003; Zerinskas & Pollio 2013). In the United States, ocelots strongly prefer dense, closed canopy thornscrub communities (Haines *et al.* 2005a). Ocelots maintain a diet of small prey (Di Bitetti et al. 2006)), with rodents and lagomorphs representing the majority of their prey (Grigione & Mrykalo 2004). Ocelots are largely solitary, with males maintaining larger territories encompassing smaller female territories (Dillon & Kelly 2008). Individuals interact primarily to mate, producing small, yearly litters after a long gestation period (Laack *et al.* 2005; Zerinskas & Pollio 2013). Following a successful brood, females maintain at least a one year interbirth period prior to reentering estrus (Laack *et al.* 2005). Two subspecies are represented in the U.S.: *L. p.albescens* in Texas and *L. p. sonoriensis* in Arizona (Zerinskas & Pollio 2013).

The ocelot’s specific ecological and behavioral requirements render it susceptible to disturbance. Anthropogenic disturbances like poaching and land conversion have taxed ocelot populations. Over 95% of the dense thornscrub that comprises the preferred ocelot habitat in Texas has undergone conversion into urban or agricultural land (Connolly 2009). This conversion had resulted in a patchwork mosaic of forest fragments, isolating ocelot populations which must disperse further to find suitable habitat. Human land use has also resulted in road construction, which serve as further barriers to movement and, through vehicle collisions, a major source of mortalities (Haines et al. 2005b). Furthermore, migration from source populations in Northern Mexico has been severed due to closed national borders (Grigione & Mrykalo 2004). This isolation has resulted in inbreeding depression, reducing adult and juvenile survivorship (Zerinskas & Pollio 2013).

**Project Objectives**

The purpose of this project was to create a habitat percent cover map, habitat probability map, and proximity map in regards to the ocelot habitat. These maps will aid the project partners in their decision making process towards ocelot conservation efforts.

**Study Area and Period**

There are two remaining regions in the United States historically known as ocelot habitat, located in Texas and Arizona. This study selected 37 counties in Texas and 6 counties in Arizona for analysis. The Texas counties comprise the southeastern most portion of the state, along the Mexico border, up to San Antonio. The area surrounding the LANWR is of particular interest to this study and is the fastest growing human border population in the United States (Haines *et al.* 2005b). The Arizona counties are also located in the southeastern most part of the state, bordering Mexico and extending up into the southern part of the Tonto National Forest.

The study period ranged from 1996 through 2014. This range of time has tracked the growth of urbanization and agriculture, as well as recent conservation efforts of private Texas landowners to convert land back to native ecosystems. Landsat imagery from January, February, or March in 1996, 2005, and 2014 were used. These months correspond to the dry seasons in the regions of interest and represent the least amount of vegetation available in ocelot habitats in that year. In the event that there was significant cloud cover, data were taken from either December or April of that year.

**National Applications Addressed**

Ecological forecasting of ocelot habitat in the United States was the focus of this project. Project deliverables will be utilized by the project partners in creating policies that promote rehabilitation efforts of the ocelot population.

**Project Partners**

The partners for this project were Mr. Ken Kaemmerer and Dr. Joseph Gaspard from the Pittsburg Zoo & PPG Aquarium, Dr. Mike Tewes and Mr. Humberto Perotto from the Caesar Kleberg Wildlife Research Institute at Texas A&M University–Kingsville, Ms. Nanette Bragin with the Denver Zoo, Mr. Mitch Sternberg with the South Texas Refuge Complex, Dr. John Young Jr. from the Texas Department of Transportation, Dr. Arturo with Secretaria de Medio Ambiente y Rescusos Naturales (SEMARNAT), and Dr. Tyler Campbell with the East Wildlife Foundation.

Currently, conservation efforts include a variety of practices, such as the use of camera trappings, radiotelemetry, translocation of Mexican ocelots, and the restoration of native vegetation in the area. These management practices can be costly and time-consuming for the partners and each technique has its limitations. Trapping and collaring ocelots is an invasive method which causes the animal undue stress. Additionally, previously trapped ocelots avoid traps in the future, further increasing the difficulty of future research. While camera trapping is a non-invasive practice, accurate assessments of population density for ocelots are difficult as trap placement bias, small sample size, repeated captures of the same individual can skew the data. The methodological framework and results of this project will be integrated into the partners’ decision-making to assess specific locations that are preferable for ocelot habitat. With this knowledge, conservation efforts will be focused for the restoration of vegetation, future translocation sites for ocelots, and the development of wildlife crossing structures for current and future road networks. Overall, the project offered the partners a methodology that will help save time and money.

# III. Methodology

**Data Acquisition**

Landsat 8 Operational Land Imager (OLI), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 5 Thematic Mapper (TM) Level 1 TIFF 30 meter resolution data products were downloaded from USGS Global Visualization Viewer website. The imagery were acquired for January through March during 1996, 2005, and 2014 and then used to derive land cover classification for each year. The land cover classifications were used to derive the change of land cover and land use over time. The classification image for 2014 was used to derive the current coverage of ocelot habitat within the study area.

Terra Moderate Resolution Imaging Spectroradiometer (MODIS) 500 meter resolution MOD09A1 data product during January through March in 2005 and 2014 were downloaded using the DEVELOP National Program Python Package (dnppy). The dnppy script for MODIS data retrieval pulled from two databases, http://e4ftl01.cr.usgs.gov and ftp://n5eil01u.ecs.nsidc.org. The data were used to derive Normalized Difference in Vegetation Index (NDVI).

Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) Level 3 30 meter resolution imagery were downloaded from the USGS Earth Explorer website. The Terra ASTER GDEM images were used to derive stream networks within the study area.

**Data Processing**

The Landsat images were processed by correcting the top of the atmosphere (TOA) reflectance by using the dnppy script. The TOA corrected images were then used in the Con tool in ArcMap 10.2.1. This tool took out any negative and zero values within the images. The images were then combined using the Composite Band tool. This tool combined the Landsat bands into a single layer and then each image was set to a specific band combination (Landsat 8 6-5-4 & Landsat 7 & 5 5-4-3). The images were then mosaicked for each year and used to derive land cover classification.

The Terra MODIS images were used to derive NDVI in ArcMap 10.2.1 using the raster calculator tool. The equation used in the tool is listed in Figure (\*).

The Terra ASTER GDEM images were used to derive stream networks within the study area using ArcMap 10.2.1. The images were then used in the following tools mosaic, fill, flow direction, flow accumulation. (Still working on this section)

**Data Analysis**

To be determined.

# IV. Results & Discussion

**Analysis of Results**

To be determined.

**Errors & Uncertainty**

To be determined.

**Future Work**

To be determined

# V. Conclusions

To be determined.

# VI. Acknowledgments

The Texas and Arizona Ecological Forecasting team would like to say thank you to the wide array of partners and mentors who provided their time, support, and expertise:

Advisors/Mentors:

* Dr. Jeffrey Luvall, NASA at NSSTC, HyspIRI Mission Deputy Program Application Lead & MSFC DEVELOP Science Mentor
* Dr. Robert Griffin, University of Alabama in Huntsville, Assistant Professor of Atmospheric Science in the Earth System Science Program

Partners:

* Ken Kaemmerer, Pittsburg Zoo & PPG Aquarium, Ocelot SSP Chair
* Dr. Joseph Gaspard, Pittsburg Zoo & PPG Aquarium, Director of Science and Conservation
* Michael Tewes, Caesar Kleberg Wildlife Research Institute at Texas A&M University–Kingsville, Frank D. Yturria Endowed Chair in Wild Cat Studies and Regents Professor
* Humberto Perotto, Caesar Kleberg Wildlife Research Institute at Texas A&M University–Kingsville, Landscape Ecologist and Assistant Professor
* Nanette Bragin, The Denver Zoo, GIS Conservation Biologist
* Mitch Sternberg, South Texas Refuge Complex, Zone Biologist-South Texas Gulf Coast
* Dr. John Young, Jr., Texas Department of Transportation, Environmental Specialist
* Dr. Arturo Caso, Secretaria de Medio Ambiente y Rescusos Naturales (SEMARNAT), Area Director
* Dr. Tyler Campbell, East Wildlife Foundation, CPO and Principle Scientist for the East Foundation

This material is based upon work supported by NASA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

# VII. References

Avila-Villegas, S., and J. A. Lamberton-Moreno. 2012. Wildlife Survey and monitoring in the Sky Island region with an emphasis on neotropical felids. Pages 441–447 Gottfried, GJ, PF Ffolliott, BS Gebow, LG Eskew, and LC Collins, comps., Merging Science and Management in a Rapidly Changing World: Biodiversity and Management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts. Available from http://www.fs.fed.us/rm/pubs/rmrs\_p067/rmrs\_p067\_441\_447.pdf (accessed June 10, 2015).

Booth-Binczik, S. D., R. D. Bradley, C. W. Thompson, L. C. Bender, J. W. Huntley, J. A. Harvey, L. L. Laack, and J. L. Mays. 2013. Food Habits of Ocelots and Potential for Competition With Bobcats In Southern Texas. The Southwestern Naturalist **58**:403–410.

Caso, A., C. Lopez-Gonzalez, E. Payan, E. Eizirik, T. de Oliviera, R. Leite-Pitman, M. J. Kelly, and C. Valderrama. 2008. *Leopardus pardalis*. Available from www.iucnredlist.org (accessed June 15, 2015).

Connolly, A. R. 2009. Defining Habitat for the Recovery of Ocelots (*Leopardus* *pardalis*) in the United States. Texas State University-San Marcos.

Di Bitetti, M. S., A. Paviolo, and C. De Angelo. 2006. Density, habitat use and activity patterns of ocelots (*Leopardus pardalis*) in the Atlantic Forest of Misiones, Argentina. Journal of Zoology **270**:153–163.

Dillon, A., and M. J. Kelly. 2008. Ocelot home range, overlap and density: comparing radio telemetry with camera trapping. Journal of Zoology **275**:391–398.

Grigione, M. M., and R. Mrykalo. 2004. Effects of artificial night lighting on endangered ocelots (*Leopardus paradalis*) and nocturnal prey along the United States-Mexico border: A literature review and hypotheses of potential impacts. Urban Ecosystems **7**:65–77.

Haines, A. M., M. E. Tewes, L. L. Laack, W. E. Grant, and J. Young. 2005a. Evaluating recovery strategies for an ocelot (*Leopardus pardalis*) population in the united states. Biological Conservation **126**:512–522.

Haines, A. M., M. E. Tewes, L. L. Laack, and Morrison. 2005b. Survival and sources of mortality in ocelots. Journal of Wildlife Management **69**:255–263.

Janecka, J. E., M. E. Tewes, L. Laack, A. Caso, L. I. Grassman, and R. L. Honeycutt. 2014. Loss of genetic diversity among ocelots in the United States during the 20th century linked to human induced population reductions. PloS ONE **9**. Available from http://dx.plos.org/10.1371/journal.pone.0089384 (accessed June 10, 2015).

Laack, L. L., M. E. Tewes, A. M. Haines, and J. H. Rappole. 2005. Reproductive life history of ocelots (*Leopardus pardalis*) in southern Texas. Acta Theriologica **50**:505–514.

Trolle, M., and M. Kery. 2003. Estimation of ocelot density in the pantanal using capture-recapture analysis of camera-trapping data. Journal of Mammalogy **84**:8.

Zerinskas, D., and C. A. Pollio. 2013. US Wildlife Management Plan: Recovery of the Endangered Ocelot (*Leopardus pardalis*) in Arizona, New Mexico, and Texas. Poultry, Fisheries & Wildlife Sciences **1**:2.

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# IV. Appendices