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NOTE

Monitoring the ocelot population in the Laguna Atascosa National Wildlife Refuge

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ABSTRACT: South Texas is home to the last remaining reproductive ocelot *Leopardus pardalis* populations in the USA. Laguna Atascosa National Wildlife Refuge hosts the southernmost Texas ocelot population, located in the eastern portion of Cameron County. The refuge has ongoing efforts to acquire, protect, and revegetate more areas in the Rio Grande Valley to promote ocelot habitat and increase connectivity of ocelot populations. To be strategic in these efforts, we monitored refuge ocelot population dynamics using remote field cameras and live-trap captures. Over the course of 10 yr, we collected photographic data from 184 camera locations and carried out 22 145 box trap-nights across the refuge to identify individuals based on their unique coat patterns and thereby maintain an ongoing population count. From January 2011 to December 2020, 40 ocelots were identified, and the monthly population ranged from 11—18 ocelots. This continuous observation and identification of individuals shows the persistence of the ocelot population at Laguna Atascosa National Wildlife Refuge. Monitoring of the refuge ocelot population is an imperative step in the conservation and survival of this federally listed endangered species.

KEY WORDS: Ocelot · *Leopardus pardalis* · Endangered species · Refuge · Remote camera · Live-trap · Population monitoring

1. INTRODUCTION

The ocelot *Leopardus pardalis* was originally listed as an endangered foreign species in 1972 (https://www.govinfo.gov/link/fr/37/6476) and then as a federally endangered native species in 1982 (https://www.govinfo.gov/link/fr/47/31670). Its presence in the USA has declined due to habitat loss and fragmentation. The ocelot is a medium-sized spotted cat that is distributed through North, Central, and South America from southern Texas to northern Argentina (Murray & Gardner 1997). Limited fossil records of ocelot specimens in Arizona (Burt 1961) and Florida (Ray et al. 1963, Kurten 1965) provide evidence that this cat once ranged well beyond modern-day Texas. Today, only 2 known breeding populations of ocelots remain in the United States, both of which occur in south Texas (see Fig. 1). One of the Texas ocelot populations is found primarily on private ranch land in Willacy and Kenedy counties, while the other population is centered on the Laguna Atascosa National Wildlife Refuge (LANWR) in Cameron County (Tewes & Everett 1986). These populations rely mostly on a habitat of dense Tamaulipan thornscrub (Navarro-

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Lopez 1985, Laack 1991, Harveson et al. 2004), most of which has been removed due to agriculture and urbanization (Tremblay et al. 2005, Leslie 2016), resulting in the isolation of these 2 populations (Janečka et al. 2011).

Recovery of the ocelot in the USA relies on increased population connectivity through habitat restoration and preservation of healthy ocelot populations (US Fish and Wildlife Service 2016). In the 1980s, there was a projected estimate of 80–120 ocelots in Texas (Tewes & Everett 1986). A study in 2005 estimated the Laguna Atascosa National Wildlife Refuge population to be 19 ocelots (Haines et al. 2005). These models provide estimates derived from habitat availability at the time. Remote cameras and trapping present the opportunity to obtain a count of individuals definitively present within the landscape.

No studies at Laguna Atascosa National Wildlife Refuge have provided a long-term population count based on monthly monitoring data, and there are generally very few long-term studies of ocelot populations, with the exceptions of research by Wang et al. (2019), which covered 7 yr in Brazil; Satter et al. (2019), 12 yr in Belize; and Lombardi et al. (2020), 7 yr in Texas. Since Texas ocelots are solitary individuals that inhabit an average of 2–4 km^2 of primarily dense thornscrub habitat (Navarro-Lopez 1985, Laack 1991), cameras and traps can be placed to optimize the capture of most, if not all, individuals within a specified area and provide an accurate assessment of the population (Dillon & Kelly 2007, Satter et al. 2019, Sternberg et al. 2023).

In this study we summarized internal US Fish and Wildlife Service reports from January 2011 to December 2020 that provided a monthly breakdown of population monitoring efforts and a count of individuals identified on the Laguna Atascosa National Wildlife Refuge. These reports were evaluated to maintain a continuous and comprehensive estimate of the refuge ocelot population (similar to a minimum number alive estimate [Krebs 1966]) based on individual ocelots identified within refuge boundaries. Through these monitoring efforts, we acquired a long-term dataset of known ocelots in the southern Texas population. These data are key in understanding the ocelot population on Laguna Atascosa National Wildlife Refuge in Texas and are a vital resource in the path to recovery for the ocelot by providing insight into small population dynamics.

2. MATERIALS AND METHODS

2.1. Study area

We surveyed the ocelot population at the Laguna Atascosa National Wildlife Refuge in Cameron County, Texas (Figs. 1 & 2). From 2011 to 2020, the refuge increased in size from 33260 to 39437 ha. This protected area is made up of a variety of different habitats including wetlands, tidal flats, coastal prairie, savannah, thornscrub, and silty-clay sand dunes. We focused our study efforts in regions of dense thornscrub, the primary habitat for ocelots across the refuge (Harveson et al. 2004).

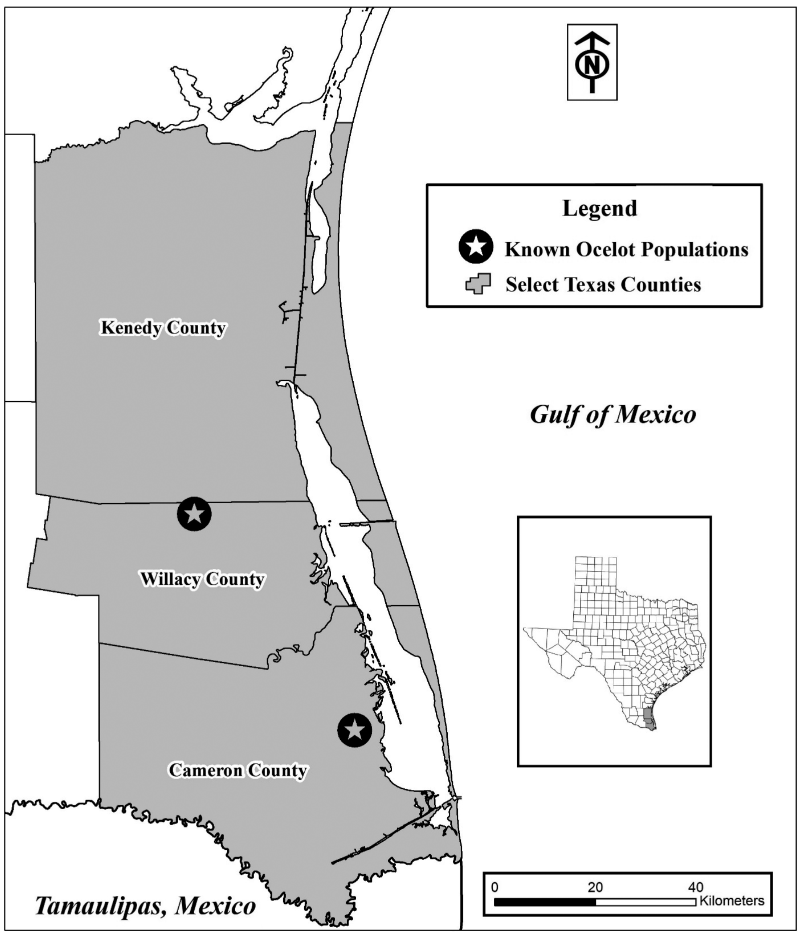

Fig. 1. Locations of the known ocelot populations in Kenedy/Willacy and Cameron counties in Texas, USA

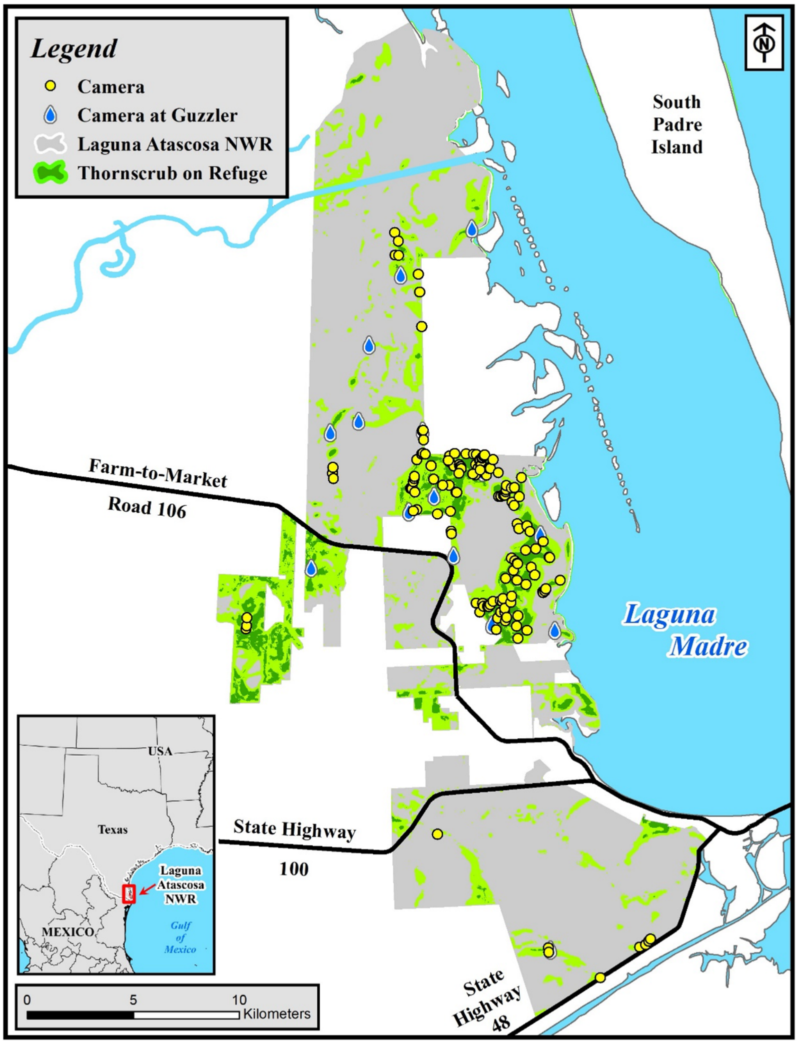

Fig. 2. Study area and camera array from January 2011–December 2020 across Laguna Atascosa National Wildlife Refuge (NWR), Texas, USA. Yellow dots represent project cameras and water drops (blue) are cameras at human-made structures known as'guzzlers' built on the refuge to capture rainwater and provide drinking water for wildlife, especially during temporary droughts. The 'thornscrub on refuge' layer was adapted with permission from Lehnen et al. (2021). The data are publicly available at https://ecos.fws.gov/ServCat/DownloadFile/197059. This layer was added to the map to visualize the areal coverage of habitat used by the ocelot around the refuge as per Harveson et al. (2004). The more dense, preferred, thornscrub is a subset of what is depicted here

2.2. Remote camera monitoring and trapping

From January 2011 to December 2020, 15 human-made water sources locally called 'guzzlers' were monitored with 1 or 2 camera traps. Cards were collected from guzzler cameras every 2 wk. Guzzler monitoring was continuous with the exceptions of relatively rare camera malfunction or intentional camera removal during public hunt periods (limited areas from mid-November to mid-January) and extremely rare times of flooding. A second set of cameras, known as 'project cameras,' were set out opportunistically to capture ocelot presence and usage across the refuge. A singular camera was set up at each of these sites. On any given month, 11–40 project cameras were deployed. These cameras were visited on a monthly basis as these camera cards did not fill as quickly as guzzler cameras. For both arrays, camera batteries were inspected each visit and changed as necessary. Vegetation was managed to prevent overgrowth and false triggering of the cameras.

Due to the extent of this monitoring effort, the number of cameras deployed at any given time varied based on availability of personnel. In addition, only project cameras that regularly photographed ocelots and did not obtain redundant information were maintained throughout the study. This project required a large inventory of cameras which varied in model and styles across location and time. Over the course of the study the following models were used: Bushnell Trophy Camera, Bushnell X-8, Cuddeback Attack, Cuddeback C123, Cuddeback Capture, Cuddeback E-2, Cuddeback Excite, Cuddeback Expert, Cuddeback Long Range IR, Reconyx PC800, Reconyx PC850, Reconyx PC90, Reconyx PC900, and Reconyx Hyperfire 2. Extreme temperatures resulted in exchanging cameras as they malfunctioned or expired.

During the 10 yr period, there were 11 trap seasons. We deployed large (single-door, bobcat traps [108 × 55 × 40 cm] and attached bait cage [50.8 × 49.5 × 38.1 cm]) and extra-large (single-door, large dog traps [122 × 66 × 50 cm] and attached bait cage [50.8 × 49.5 × 38.1 cm]) traps with bait cages (Tomahawk Live Trap Co.) containing live pigeons. Due to the semi-arid conditions at the refuge, trap nights only occurred when temperatures were below 32°C for the safety of any captured animals. Trapping was suspended if temperatures dropped below 7°C. With these guidelines, trap season ranged 4 to 8 mo from the fall (October–December) through late spring (March–June). Up to 50 traps were set across multiple trap lines each season. Photos of ocelots following sedation and during handling were used to identify ocelots photographed by cameras. Trapping and handling protocols followed those of Sternberg & Swarts (2021).

2.3. Ocelot identification and monthly reporting

Ocelots were identified using the coat pattern unique to each individual (Dillon & Kelly 2007, Sternberg & Mays 2011). Technicians were trained to identify ocelots in photographs by using 3 unique markings per individual ocelot. Ocelots were named according to the species as ocelot (O), sex (M or F), and a sequential 3-digit number (e.g. OM331). At the time of sorting, ocelots that were photographed and did not match any known individual were denoted as ocelot anonymous (OAN) until further documentation of the individual could provide enough images of the coat pattern for definitive identification. For example, if only the left side of an ocelot was photographed and it was not any known individual in the count, this would be an OAN until we had a series of photos to adequately identify the individual from multiple angles and determine its sex. This ensured that we would not double count the individual by giving it 2 different identifiers. Often, multiple OAN photos were from the same individual, at which time the photos were plentiful enough to provide a unique identifier to the ocelot, and this was corrected in the post processing of the monthly data. If a photograph documented an ocelot was not of sufficient quality to distinguish a definitive coat pattern, the designation as ocelot unidentifiable (OUN) was used.

Monthly internal reports documented the results of field activities. Reports contained the known count of ocelots on the refuge including kittens, juveniles, and adults. This count included identified ocelots and OANs, but did not include the encounter history for each individual. For the purpose of the present study, monthly reports were post-processed to confirm all OANs were not later identified as a known individual in order to ensure that no individual was double-counted. OUNs were not included in the count since those photographs did not provide enough information to determine whether it was an identified ocelot already accounted for in the population.

When an ocelot mortality occurred, the individual was considered part of the population during the month in which the mortality occurred and removed from the population count in the following month's report. Even if an ocelot was not captured on camera or trapped within a month, it remained in the count. Once individuals had not been documented in 2 yr, they were removed from the population count in the monthly report after the 2 yr period ended. This time period was established by ocelot biologists to prevent the overestimation of the refuge population and to account for mortalities or emigration that were not detected via remote camera. This also provided a buffer for month-to-month differences in sightings on the cameras. However, we continued to check any new ocelot marking against ocelots that had been removed from the count unless there was a known mortality. There was only 1 instance when a female ocelot was not detected for 2 yr, was removed from the monthly reports, but was detected 3 mo after being removed, and therefore that female was added back into the running population count.

3. RESULTS AND DISCUSSION

3.1. Summary of monthly report data

During the 10 yr period, cameras were deployed at 184 different locations across the refuge. There were 22 145 box trap-nights during which there were 68 ocelot live-captures of 24 different individuals. Including all camera and trap data, 40 ocelots were identified, consisting of 20 males, 12 females, and 8 individuals whose sex was never determined (Fig. 3; Table S1 in the Supplement at www.int-res.com/articles/suppl/n055p261_supp.xlsx). The monthly counts ranged from 11–18 ocelots. From January 2011 to December 2020, 10 (8 male, 1 female, 1 unknown) ocelot mortalities from the refuge population were reported. Necropsies for cause of death determined that 6 of these refuge ocelots were killed by vehicle collision, while the cause of death of the others was undetermined either due to the compromised condition of the carcass or general idiopathology. As of December 2020, the population count included 17 ocelots. The 13 ocelots unaccounted for at the end of the 10 yr study period were removed from the count throughout the study as there had been no detections of these individuals for over 2 yr.

While there were 27 ocelots added to the refuge count and 23 individuals were removed from the refuge population estimate between January 2011 and December 2020, the population was essentially static despite some minor fluctuations. There were 13 ocelots estimated in January 2011 and 17 ocelots estimated in December 2020, showing the relative stability and potential growth of the refuge subset of the Cameron County ocelot population. However stable the population, smaller and isolated populations face

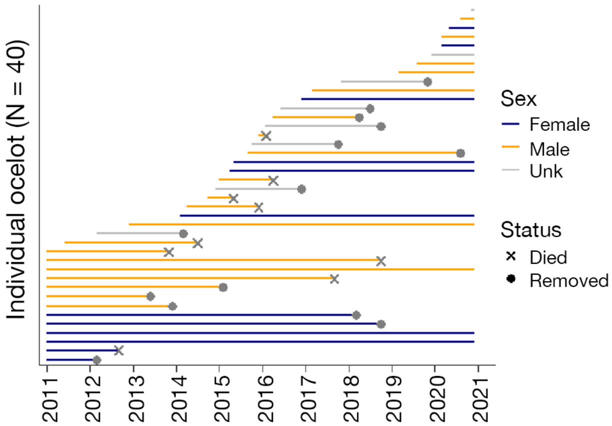

Fig. 3. History of individual ocelots identified at Laguna Atascosa National Wildlife Refuge and their status in the monthly population count 2011–2020. Unk: unknown; Removed: removed from the population count

great extinction risk (Wootton & Pfister 2013). These counts were within the estimated range of the carrying capacity for the refuge population (i.e. 19) considering environmental variation (±4.4 ocelots) by Haines et al. (2005). The habitat-based population viability model of Haines et al. (2006) demonstrated that the single most effective recovery strategy included a population of 18 ocelots and the protection of 3 habitat patches. Given these criteria, and that ocelots continue to occupy the same patches from the 1990s, the refuge ocelot population seems secure at the moment. Yet, additional habitat is needed to expand the population and to connect the 2 Texas populations (US Fish and Wildlife Service 2016). Without genetic interchange between the Texas populations and other populations, particularly the populations in Tamaulipas, Mexico, per the specific recommendation from Janečka et al. (2014), Texas ocelots are at continued risk for loss of genetic diversity and inbreeding depression.

3.2. Limitations of the data

The internal, monthly reports that were started in 2010 of the ocelot population on Laguna Atascosa National Wildlife Refuge provided a frequent and continuous status of the population for decision-makers, helping to inform recovery actions through improved management. After 10 yr of instituting this protocol, the value of the sizable dataset we had amassed became apparent. Without the capacity for an in-depth research project, some limitations on the use of the data are inevitable; however, the value of the data towards conservation actions outweighs the study limitations. This was a large-scale project with finite, variable resources, and carried out by a small team. We instituted an atypical camera array which involved yielding as much data as possible from the effort. As such, we removed or added cameras after meticulous discussion about the efficacy of time spent in areas where there was a redundancy in captures or a lack of captures. We recognize this may have inhibited the utility of the dataset and acknowledge the utility of periodic mark–recapture studies (Sternberg & Mays 2011); however, given our diligence selecting camera locations, we feel confident that the information gathered derived a comprehensive estimate of the ocelot population on the refuge.

3.3. Implications

Long-term monitoring of ocelots at Laguna Atascosa National Wildlife Refuge has provided not only a count of individuals, but also insight into the number of ocelots the refuge can support and the threats faced by the ocelots that live within the area. The consistent acquisition, analysis, and reporting of data from the ocelots within the refuge population allowed conservation managers the direct, immediate opportunity to understand and share with partners how best to manage the landscape for this population. Regular monitoring and management of this population ensured that recommended recovery efforts were well-informed, and were executed in policy and action in an adaptive management framework. Recovery actions were implemented as the direct result of the long-term monitoring of this population, and included strategic land acquisition, a renewed and focused effort on thornscrub restoration since 2017 (Lehnen et al. 2021), and building habitat contiguously out from existing habitat used by the population. This research also contributed to the collaboration of US Fish and Wildlife Service with Texas Department of Transportation that led to the installation of numerous ocelot underpasses throughout the local area (Schmidt et al. 2020, 2021).

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