

**Species Status Assessment Report**  
**For**  
**Northern Aplomado Falcon**  
*(Falco femoralis septentrionalis)*



*Northern Aplomado Falcons in south Texas.*

*Photo: Paul Juergens*

**July 2025**  
**U.S. Fish and Wildlife Service**  
**Corpus Christi, Texas**  
**Version 1.0**

## **Disclaimer:**

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Valuable input and data were provided by *The Peregrine Fund, Boise, Id., Ray Meyer, La Tierra Environmental Consulting, Las Cruces, New Mexico., and Mitch Sternberg (USFWS)*. Technical and peer reviews of drafts of this document were provided by Chris McClure and Brian Mutch (Peregrine Fund), Chris Perez (USFWS-Retired), Julio Gallardo del Angel (Species Expert), and Raymond Meyers (La Tierra Consulting). We appreciate their input and comments, which resulted in a more robust Species Status Assessment.

### Suggested reference:

U.S. Fish and Wildlife Service. 2025. Species status assessment report for northern aplomado falcon (*Falco femoralis septentrionalis*), Version 1.0 July 2025, Corpus Christi, Texas.

## EXECUTIVE SUMMARY

This Species Status Assessment (SSA) reports the results of the comprehensive status review for the northern aplomado falcon (*Falco femoralis septentrionalis*). The northern aplomado falcon is a rare, non-migratory, medium-sized Neotropical falcon of the open grasslands ranging from the southwestern U.S. and Mexico to Central America. This subspecies was listed as endangered in 1986 due to its extirpation as a breeding bird in the U.S., and evidence of pesticide contamination and population declines in eastern Mexico (51 FR: 6686). Following its listing, a recovery plan for the northern aplomado falcon was released in 1990 outlining actions to address the causes of extirpation and set goals for downlisting. Since that time, several recovery actions have been implemented such as a successful reintroduction effort in coastal Texas. Other activities centered around land protection and enhancement efforts as well as a captive breeding program established by The Peregrine Fund. To date, the subspecies is still at risk by a number of threats including, but not limited to, habitat loss and lack of connectivity between the three identified populations described in this report; the Coastal Texas, Chihuahuan Desert, and Tropical Lowlands populations. This SSA report will be used to update the species' recovery plan to reflect current status and recovery to date as well as to inform future recovery needs.

This SSA report provides an in-depth review of the species' biology, resource needs, and stressors, an evaluation of the current status, and an assessment of the resources and conditions needed to maintain long-term viability. Using the SSA framework, species viability is considered by characterizing the status of the species' resiliency, redundancy, and representation, referred to as the 3Rs. This report will be used to inform a 5-year status review and a revised Recovery Plan. To evaluate the potential future biological condition of the northern aplomado falcon, we assessed a range of possible future conditions, including future stressors and conservation actions to allow us to consider the resiliency, redundancy and representation of the species into the future. Habitat loss or alteration, exacerbated by environmental changes and human development, was identified as major stressors considered within our analysis of future species viability.

For the northern aplomado falcon to maintain viability, its populations must be able to withstand stochastic events. Demographic factors such as fecundity and breeder survival; population abundance, distribution, and connectivity; nest site availability; and dispersal influence the viability of northern aplomado falcon populations. Influencing these factors are elements of habitat that determine whether northern aplomado falcon populations can grow to carrying capacity, thus increasing the resiliency of populations. To assess the current resiliency of the three wild populations of northern aplomado falcons (Coastal Texas, Chihuahuan Desert, and Tropical Lowlands), we quantified the demographic and habitat factors described in the Population Resiliency Factors section and Table ES-1 below. These factors include fecundity, breeder survival, abundance, distribution, connectivity, nest site availability, and dispersal and assessed the current overall condition of each population based on its average condition category across these demographic and habitat factors, with all factors weighted equally (Table ES-2). Currently, the Coastal Texas and Chihuahuan Desert populations have low condition, and the Tropical Lowlands population is in moderate condition. Although there are three known populations of northern aplomado falcons, two populations are currently in low resiliency condition, suggesting that redundancy is not secure for the subspecies. Further, there is no known connectivity between the existing populations. Although populations are geographically separate,

which limits the risk of any single catastrophic event impacting the entire subspecies, retaining population redundancy requires conservation actions that increase the resiliency of the Chihuahuan Desert and Coastal Texas populations. Representation in the form of genetic or ecological diversity is important to maintain the capacity of northern aplomado falcons to adapt to future environmental changes. Although juveniles are capable of dispersing long distances, current populations are separated by at least 373 miles, suggesting they do not interact with each other. Further supporting this, Rolek et al. (2022, p.9) found immigration of non-breeders and emigration negligible, suggesting an isolated population in coastal Texas. The northern aplomado falcon has likely lost genetic diversity following the local extirpation of the species from coastal Texas and the drastic declines experienced in the Chihuahuan Desert. Of the existing populations, only two (Tropical Lowlands and Chihuahuan Desert populations) possess unique genetics, as all individuals in coastal Texas are captive-born progeny of birds sourced from the Tropical Lowlands population in Mexico. The use by northern aplomado falcons of multiple grassland types indicates a level of ecological diversity that would likely allow for adaptation to changes in the environment over time, provided adequate prey abundance and nest site availability.

Because future stressors and levels of conservation efforts are uncertain, we assessed three plausible future scenarios (Table ES\_3). These future scenarios forecast the viability of northern aplomado falcons based on different potential levels of habitat loss from human development and sea level rise, increasing risk of major hurricanes and long-term drought, and conservation actions on corresponding timelines over the next 45 to 60 years. Future land use projections for the SSA report were derived from (2020 USGS LCMMap data) compared with EPA ICLUS (Integrated Climate and Land Use Scenarios) V.2, 2080 data. Both datasets were reclassified (slightly simplified) and projected to match to identify the differences between the 2 datasets. The land use changes from 2020 to 2080 were then calculated for the report. The three scenarios do not include all possible combinations of future impacts and conservation efforts, and there is uncertainty associated with them, but they represent estimated timelines thought necessary for implementation of conservation measures under varying levels of increasing stressors. We assume that all the conservation measures are successfully implemented within the associated timeframes. Under all scenarios, all populations are expected to be in a future overall moderate resiliency condition (Table ES-4). Achieving the conservation measures as outlined will increase the species' redundancy and secure current levels of species representation, because all three populations are retained, and both the Coastal Texas and Chihuahuan Desert populations are expected to be more resilient to stochastic and catastrophic events in the future. However, conservation measure implementation is most urgent for the Chihuahuan Desert population. If conservation actions are not implemented prior to a catastrophic event occurring, the Chihuahuan Desert population could be lost, and genetic and ecological representation could be negatively impacted or lost.

Table ES-1. Condition category definitions for northern aplomado habitat and demographic resiliency factors.

<b>Condition Category</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>
<b>High</b>	>2.0	0.92+	≥50 pairs (Ne) in populations	Distributed in such a way that catastrophes impact less than 20% of the population over 20 years	Populations are less than 80 miles apart	Stick nests available - in yuccas or tall trees with bromeliads (in tropical lowlands)	Ample resources are available, and females establish breeding territories outside of their natal territory
<b>Moderate</b>	1.2 - 2.0	0.9 - 0.92	<50 >25 pairs (Ne) in populations	Distributed in such a way that catastrophes impact no more than 30% of the population and occur less than once every 20 years	Populations are between 80 miles and 230 miles apart	Combo of natural stick nests in yuccas and artificial structures	This factor is not defined for moderate condition.
<b>Low</b>	<1.2	< 0.9	<25 pairs (Ne) in populations	Distributed in such a way that catastrophes impact 30% or more of the population	Populations are greater than 230 miles apart	Artificial structures available and natural stick nests in shrubs or on ground	Resources are limited and females return to their natal territory to breed

Table ES-2. Northern aplomado falcon current resiliency.

<b>Population</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>	<b>Current Condition</b>
Coastal Texas	Moderate	Low	Low	Low	Low	Moderate	High	Low
Chihuahuan Desert	Low	Low	Low	Low	Low	Moderate	Low	Low
Tropical Lowlands	Low	Low	High	Moderate	Low	High	High	Moderate

Table ES-3. Summary of future scenarios.

<b>Scenario</b>	<b>Stressors</b>	<b>Conservation actions completed by:</b>
1	Continuation of current trends	2080
2	Moderate stressor increase	2074
3	Greater stressor increase	2068

Table ES-4. Species Status Assessment for northern aplomado falcon under current conditions and future scenarios of decreased stressors, status quo, and increased stressors.

<b>Population</b>	<b>Habitat Type</b>	<b>Current Condition</b>	<b>Scenario1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>
Coastal Texas	Coastal Prairie	Low	Moderate	Moderate	Moderate
Chihuahuan Desert	Chihuahuan Desert	Low	Moderate	Moderate	Moderate
Tropical Lowlands	Open Pastures, Cut-over Rain Forest	Moderate	Moderate	Moderate	Moderate

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# 1 INTRODUCTION

## 1.1 Background Information on the Northern Aplomado Falcon

The northern aplomado falcon (*Falco femoralis septentrionalis*) is a rare, non-migratory, medium-sized Neotropical falcon of the open grasslands ranging from the southwestern U.S. and Mexico to Central America. The northern aplomado falcon was listed as endangered in 1986 due to its extirpation as a breeding bird in the U.S., and evidence of pesticide contamination and population declines in eastern Mexico (51 FR: 6686). Following its listing, a recovery plan for the northern aplomado falcon was developed in 1990 outlining actions to address the causes of extirpation and set goals for downlisting. Hector (1981, pp. 6-13; Hector 1987, p. 384) states that the northern aplomado falcon's decline in the U.S. may have begun as early as 1905 but the species became exceedingly rare after 1930. The majority of northern aplomado falcon egg and skin collections in the U.S. between 1890 and 1910 originated from southern Texas (Hector 1981, pp. 9-10, Table VII; USFWS 1990, p. 1). Egg collection cards and other historical records (Oberholser 1974, pp. 256-258, Vol 1) indicate that the species was concentrated in the "salt prairie" between Brownsville and Port Isabel, as this is where major collecting activities were occurring in the late 1800s-early 1900s. It is therefore plausible that the initial decline of the northern aplomado falcon in south Texas was due to over-collection rather than from widespread habitat degradation which occurred in the late 1800s-early 1900s within the Chihuahuan Desert grasslands of west Texas, southern New Mexico and parts of southeastern Arizona. In fact, Hector (1981, pp. 8-9, p. 88) confirms that, in addition to brush encroachment of its habitat in the southwestern US, other factors associated with its decline included over-collecting and reduced nest availability due to declines of certain nest constructors. Northern aplomado falcons were first known from the U.S. from a specimen collected in southwestern New Mexico in 1852 (Hector 1981, p. 5). Hector (1987, p. 385), after Buffington and Herbel (1965, entire) noted extensive brush encroachment on the Jornada Del Muerto grassland in southern New Mexico beginning in 1858 through 1963, which converted the area from a grassland to high densities of brush in an area that formerly "...contained the highest known nesting densities of Aplomado Falcons outside of South Texas." Prior to listing, the last U.S. nest documented was near Deming, New Mexico in 1952 (Ligon 1961, p. 82).

The Northern Aplomado Falcon Recovery Plan (USFWS 1990, p. 24, p. 111) states that "...suitable habitat in the United States and Mexico should be identified and protected, especially in areas close to reintroduction sites." It goes on to stress that, "Particular attention should be directed toward suitable habitat on public lands." Other elements of the Recovery Plan emphasize a reintroduction program to establish populations in the U.S. The criterion for downlisting the aplomado to threatened is when a "...minimum self-sustaining population of 60 breeding pairs has been established in the United States." The northern aplomado falcon has successfully been reestablished in south Texas due to the recovery program involving captive breeding and reintroduction efforts. However, reintroduction efforts in the Chihuahuan Desert grasslands in southern New Mexico and west Texas have not been successful. In the adjacent Chihuahuan Desert grasslands in Chihuahua, Mexico, a small desert-breeding population of northern aplomado falcons currently exist in the wild. In the tropical lowlands, detailed information on the subspecies distribution is currently lacking. For more detailed population descriptions, see Chapter 3.2 Current Distribution.

## 1.2 Species Status Assessment Framework

The Species Status Assessment (SSA) framework (USFWS 2016b, entire) is intended to support an in-depth review of a species' biology, resource needs, and stressors, an evaluation of its current status, and an assessment of the resources and conditions needed to maintain long-term viability. The SSA process is an analytical process that culminates in a report. The intent is for the SSA report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program. As such, the SSA report will be a living document upon which other documents, such as listing rules, recovery plans, and 5-year reviews, would be based if the species continues to warrant listing under the Endangered Species Act (ESA).

For the northern aplomado falcon, this SSA report will be used to inform a 5-year status review and a revised Recovery Plan. Available information and scientific analysis are contained in this SSA report. The report does not provide decisions; instead, it provides a review of available information related to the northern aplomado falcon's current and potential future biological condition for consideration when making a status recommendation through the 5-year review process and for revising the current Recovery Plan. This report was peer reviewed following guidance provided in the August 22, 2016, Peer Review Process memorandum (USFWS 2016a, entire).

For the purposes of this assessment, viability is defined as the ability of northern aplomado falcons to sustain populations in the wild over time. Using the SSA framework (Figure 1.1), the requirements needed to maintain species viability are considered by characterizing the status of the species' resiliency, redundancy, and representation, referred to as the 3Rs (Wolf *et al.* 2015, entire; Smith *et al.* 2018, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events arising from random factors. Resiliency can be measured based on metrics of current population condition including, for example, abundance, population growth rates, and habitat availability. Highly resilient populations are better able to withstand stochastic disturbances such as random fluctuations in birth rates (i.e., demographic stochasticity), variations in rainfall or temperature (i.e., environmental stochasticity), or the effects of anthropogenic activities.
- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution and connectivity, redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (e.g., a rare destructive natural event or episode involving many populations, such as a hurricane).
- **Representation** describes the ability of a species to adapt to longer-term changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity among populations and gauges the probability that a species can adapt to environmental changes. The more representation, or diversity, a species has, the more it can adapt to changes (natural or human caused) in its environment. In the absence of species-specific population genetic information, representation is evaluated based on the extent of ecological diversity or variability in habitat characteristics across the geographical

range.

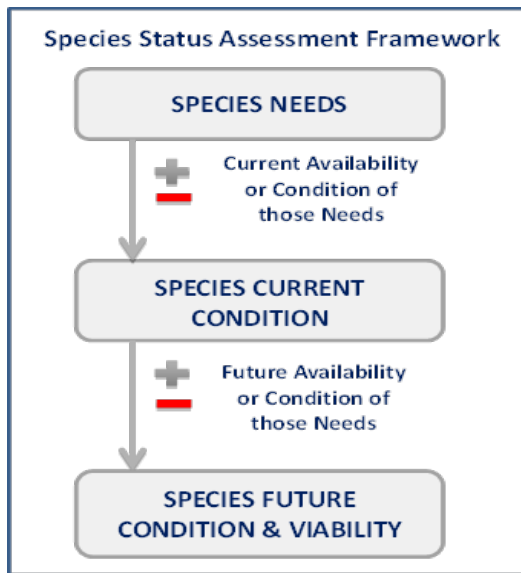


Figure 1.1 Species Status Assessment Framework.

To evaluate the potential future biological condition of the northern aplomado falcon, we assessed a range of possible future conditions, including future stressors and conservation actions, to allow us to consider the resiliency, redundancy and representation of the species into the future. This report assesses the risks and ongoing and future conservation potentially acting on the northern aplomado falcon in the context of evaluating the species' viability into the future. The best available scientific and commercial information was used to describe the past, present and plausible future status of the northern aplomado falcon viability in terms of resiliency, redundancy and representation under various possible future scenarios (Chapter 6).

## 2 SPECIES BIOLOGY AND INDIVIDUAL AND POPULATION NEEDS

Basic biological information about the northern aplomado falcon is addressed in this chapter, including its morphological description, taxonomic history and relationships, reproductive and other life history traits and resource needs, including the habitat types used for nesting and foraging.

### 2.1 Species description

The aplomado falcon (*Falco femoralis*) is a colorful, medium-sized raptor inhabiting lowland Neotropical savannas, coastal prairies and higher elevation grasslands from the southwestern United States to Tierra del Fuego, South America (Keddy-Hector *et al.* 2020, accessed September 2023). This falcon measures a total length of about 38-43 centimeters (cm) (15–17 inches (in)) and weighs between 208-500 grams (g) (0.46-1.0 pounds (lbs)), about the size of a Cooper's hawk (Keddy-Hector *et al.* 2020, accessed September 2023) with a wingspan of approximately 0.9 meters (m) (3 feet (ft)).

The upperparts of adults are described as slate to bluish grey or leaden colored, as the Spanish name for "aplomado" means "lead colored." The head features a bold black-and-white striped

pattern, and its underparts are tri-colored with a whitish to buffy colored upper breast and a blackish “belly band” separating a cinnamon belly and undertail coverts (Keddy-Hector *et al.* 2020, *accessed* September 2023). The tail is banded with a black-and-white pattern. Females are slightly larger and heavier than males (Keddy-Hector *et al.* 2020, *accessed* September 2023).

Juveniles are more brownish than adults. The head features a bold black-and-cinnamon striped pattern, and the breast is cinnamon with bold dark streaking (Oberholser 1974, p. 256; Keddy-Hector *et al.* 2020, *accessed* September 2023). In flight, the upperparts appear dark with a silver trailing edge on the wings. The northern aplomado falcon flies swiftly with deep rapid wingbeats, but also utilizes slow-flapping, gliding or hovering flight (Keddy-Hector *et al.* 2020, *accessed* September 2023).

Three subspecies of aplomado falcon, that vary by size and plumage color, are generally agreed upon (Keddy-Hector 2019, p. 118). The northern aplomado falcon, the only aplomado falcon found in the United States; the nominate subspecies (*Falco femoralis femoralis*) found in Central and South America, and *Falco femoralis pichincae* a high elevation subspecies found in the Andes of South America. The northern aplomado falcon is larger than the nominate subspecies and more greyish than other subspecies dorsally. In the Chihuahuan Desert, northern aplomado falcon wing chords average 7-8.5% larger than northern aplomado falcons in the tropical lowlands of Mexico, whose wing chords average 6.2-3.2% larger than the nominate subspecies (Blake 1977 as cited in Montoya 1995 p. 59; Keddy-Hector 2019, pp.116-118).

## 2.2 Taxonomy

The Service recognizes the following taxonomic nomenclature for the northern aplomado falcon as follows:

Kingdom: Animalia

Phylum: Chordata

Class: Aves

Order: Falconiformes Family: Falconidae Genus: Falco

Species: *Falco femoralis* (Temminck 1822)

Sub-species: *septentrionalis*

According to the 1990 Recovery Plan (page 3), the subspecies was described in 1916 from a specimen collected at Fort Huachuca, Arizona in 1887, and was distinguished from the geographically adjacent nominate subspecies (*F.f. femoralis*) based on morphometric differences and darker color. These diagnostic characters intergrade between the northern and nominate subspecies (USFWS 1990, p. 5). The northern subspecies is distributed from southern Texas and New Mexico extending down through Mexico and along Central America’s Pacific slope, while the nominate subspecies is distributed along Central America’s Caribbean Coast from Belize down into South America (USFWS 1990, pp. 4-5). EBird sightings suggest that the northern and nominate subspecies distribution are contiguous across the Yucatan Peninsula. Since:

- the northern subspecies was described before molecular genetics were well understood,
- the northern subspecies is distinguished from the adjacent nominate subspecies based on

characters that are consistent with Bergmann's rule (i.e., species tend to be larger in colder environments and smaller in warmer environments) (Bergmann 1847, entire; Keedy-Hector 2019, pp. 118-120) rather than variable environmental effects on individuals distributed throughout different parts of the range.

- the characters used to distinguish the northern subspecies from the nominate subspecies intergrade between the two subspecies, and there is evidence that the northern and nominate subspecies distributions may be contiguous with one another.

Therefore, the northern subspecies taxonomy bears reexamining to determine whether there is any significant difference between it and the nominate subspecies, and whether any such differences result from heritable traits, or result from environmental influences.

### 2.3 Life History

The northern aplomado falcon has five life stages: egg (~32 days to hatching), nestling (hatch to fledging at approx. 5 weeks), fledgling (approx. 5 weeks to 4 months), juvenile (4 months to ~1 year), subadult (1-2 years) and adult (2+ years) (Figure 2.1). Northern aplomado falcons are presumed to be monogamous and once paired, remain together year-round and hunt cooperatively (TPWD 1986, p. 2; Keddy-Hector *et al.* 2020, accessed September 2023). Although not much information on reproductive maturity has been collected, information from Mexico suggests that females can reproduce at the end of their first year (Keddy-Hector *et al.* 2020, accessed September 2023). In the Coastal Texas and Chihuahuan Desert populations, monitoring crews have observed productivity from end of first year females and males and even end of first year females paired with end of first year males (B. Mutch, pers. comm., March 25, 2025).

Eggs are whitish or buffy in color with light to dark brown or rusty colored spots and blotches. They are smooth and considered short elliptical in shape. Dimensions are approximately 43-44 millimeters (mm) (~1.7 in) in length and 34 mm (1.3 in) in breadth (Keddy-Hector *et al.* 2020, accessed September 2023). Incubation lasts approximately 32 days until hatching.

At hatching, chicks are white and helpless (Keddy-Hector *et al.* 2020, accessed September 2023). They molt into a grayish-dusky second natal down at 1-2 weeks and attain a juvenile plumage between 2-6 weeks of age (Hector 1981, p. 105, p. 107; Keddy-Hector *et al.* 2020, accessed September 2023). Fledging generally occurs 4 to 5 weeks after hatching (Keddy-Hector *et al.* 2020, accessed September 2023).

Little is known about survival or life spans in the wild; however, relatively high adult survival in a reintroduced population suggests the northern aplomado falcon may have a "slow" life-history strategy (Brown and Collopy 2008, p. 105). Brown *et al.* (2006, p. 456) documented apparent annual survival rates of juveniles (0.374), non-breeding adults (0.872), and breeding adults (0.910). In captivity, male northern aplomado falcons have lived to 23 and 24 years of age, and one female lived to 20 (Heinrich 2011 as cited in Keddy-Hector *et al.* 2020, accessed September 2023). In the wild, survival to a minimum of 6 years of age has been documented through recaptures, and one captive-reared and released northern aplomado falcon was found dead at 8 years of age (Keddy-Hector *et al.* 2020, accessed September 2023). From band reading and

recaptures, both males and females have survived to a minimum of 12 years of age and female productivity observed to approximately 10 years of age (B. Mutch, pers. comm., March 25, 2025).

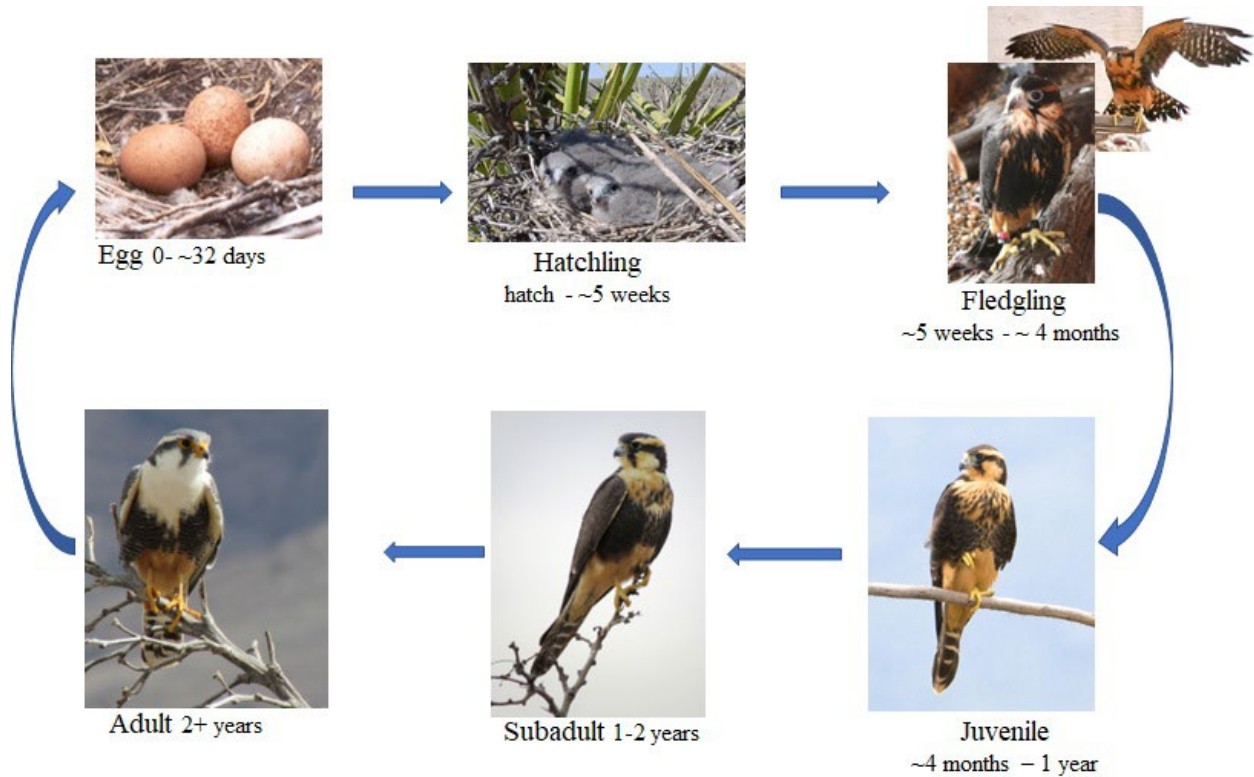


Figure 2.1. Life cycle diagram of the northern aplomado falcon. *Photo credit: Alberto Macías-Duarte.*

### 2.3.1 Breeders/Adults

Adult northern aplomado falcons usually occur in pairs over most of the geographic range of this species (Keddy-Hector *et al.* 2020, accessed September 2023). They are primarily non-migratory in the U.S. with mated pairs remaining together year-round in the same territory (USFWS 2014, p. 6). Breeding pairs tend to exhibit strong nesting territory fidelity. Mated pairs tend to hunt and feed together and perch near each other throughout the year and not just during breeding season (Keddy-Hector *et al.* 2020, accessed September 2023). Northern aplomado falcons reach sexual maturity at the end of their first year, but generally do not form a pair bond until the spring of their second year. Courtship is characterized by display soaring and flying, courtship feeding, and nest displays (Keddy-Hector *et al.* 2020, accessed September 2023). Northern aplomado falcons do not construct their own nest platforms, but instead use stick platforms built by other birds, such as other raptors, crested caracaras (*Caracara plancus*) and large corvids (Keddy-Hector *et al.* 2020, accessed September 2023; Hector 1987, p. 388; USFWS 2014, p. 6; USFWS 1990, p. 12). These are most often in yuccas (*Yucca* spp.) or mesquite (*Prosopis glandulosa*) (Montoya *et al.* 1997, entire).

Breeding adult northern aplomado falcons generally require smaller home ranges than non-breeding northern aplomado falcons. Home range estimates for northern aplomado falcons ranged from 3.3 to 21.4 km<sup>2</sup> (Montoya *et al.* 1997, p. 138) but more recently, a home range size

estimate of 200 km<sup>2</sup> was documented for a breeding pair, using satellite telemetry from an individual male (Macías-Duarte *et al.* 2021, p. 271). In comparison, non-breeding season home range estimates for juvenile northern aplomado falcons ranged from 36 to 281 km<sup>2</sup> ( $\bar{x}$  = 112 km<sup>2</sup>) (Perez *et al.* 1996, p. 177). Primary nesting occurs from February through June in northern portions of the range, with aerial courtship displays being observed as early as late January and early February (Keddy-Hector *et al.* 2020, accessed September 2023). In Chihuahua, average incubation start date ranged from February 28 to April 5 from 1996 to 2002, with the earliest and latest nests starting on February 9 and May 12, respectively (Macías-Duarte *et al.* 2004, p. 1085). In the tropical lowlands of Mexico, nesting may begin as early as January through June, while in the U.S., nests with eggs were noted from April through May (USFWS 1990, p. 18). Clutch size is typically 2-3 eggs, averages 2.6, and rarely contains 4 (Hector 1987, p. 384; USFWS 1990, p. 19). Incubation lasts approximately 32 days, with females incubating the majority of this time, although males will occasionally share this activity. Males frequently hunt alone, especially during incubation, with females occasionally participating in hunting. The young fledge in about 5 weeks (Hector 1981, p. 105). In Chihuahua, a fraction of nesting pairs produce a second clutch each year (A. Macías Duarte, pers. comm., May 7, 2024).

### 2.3.2 Fledglings and Juveniles

Fledglings generally remain in the vicinity of the nest for at least a month after fledging (Keddy-Hector *et al.* 2020, accessed September 2023) but can remain up to three months (Montijo-Tautimes 2021, p. 32). Prior to developing effective flying skills, they are vulnerable to terrestrial predators, such as bobcats (*Lynx rufus*) and coyotes (*Canis latrans*), if they spend too much time on the ground, or even to snakes while perched or roosting in a tree. When flying, they are vulnerable to capture by red-tailed hawks (*Buteo jamaicensis*), Harris' hawks (*Parabuteo unicinctus*), great horned owls (*Bubo virginianus*), and other birds of prey. If a young northern aplomado falcon can survive the first year of its life, chances are good that it will survive into adulthood (Hector 1981, p. 85). Perez *et al.* (1996, p. 177) documented that released young northern aplomado falcons generally survived after 2-4 weeks post-release.

### 2.3.3 Habitat

Northern aplomado falcons live in open habitats with some shrubs or trees for nesting. This includes desert grasslands, savannas, and shrub-steppe habitats, and can include open pastures. In the tropical lowlands of eastern Mexico, this can include open savanna areas within the dominant forested habitat.

In coastal Texas, the northern aplomado falcon inhabits coastal grasslands and tidal flats with prominent scattered woody vegetation, typically a flat open area with low growing vegetation and containing yuccas or trees (Figure 2.2). Most foraging areas contain small honey mesquites and treel yuccas (*Yucca treculeana*) on higher elevations overlooking salt flats or wet marshy areas in depressions (Perez *et al.* 1996, p. 178). The habitat on Laguna Atascosa National Wildlife Refuge (NWR) where captive-reared northern aplomado falcons were released between 1993 and 2004 is composed primarily of marshy wetland, coastal prairie, thorn scrub, savanna, grassland, and cropland vegetation types, in order of abundance. Taller and denser vegetation tends to dominate roost sites while shorter and less dense vegetation tends to dominate foraging areas. Mesquite, acacia (*Acacia smallii*) and yucca tend to be the dominant woody plant

vegetation around roost sites, while honey mesquite, sea oxeye (*Borrchia frutescens*) and prickly-pear cactus (*Opuntia lindheimeri*) are the dominant woody plant species in foraging areas in Texas coastal habitat (Perez *et al.* 1996, pp. 177-178). Woody vegetation densities in foraging areas range from 0.5-83.8 plants/ha and 1.6-14.9 plants/ha at roost sites (Perez *et al.* 1996, p. 179). Ground cover averages 46 +/- 9 percent at roost sites and 60.2 +/- 5 percent at foraging sites (Perez *et al.* 1996, p. 179). However, in foraging areas, the dominant vegetation only ranges from 8-15 cm (~3-6 in) tall while the dominant vegetation in roost areas consisting of Gulf cordgrass is much taller and denser (Perez *et al.* 1996, p. 181).

Within the Chihuahuan Desert, northern aplomado falcons typically occur in open grassland areas with scattered mesquite (*Prosopis*), soap tree yucca and Torrey yucca (*Yucca elata* and *Y. torreyi*) (Figure 2.3: Ligon 1961, pp. 81-82; Montoya *et al.* 1997, p. 138, p. 140; Macías-Duarte *et al.* 2004, p. 1084). Woody vegetation densities in home ranges of northern aplomado falcons in the Chihuahuan Desert grasslands of Mexico vary from 11.2 to 139.5 plants/hectare (ha), with no significant difference between nesting and non-nesting territories (Montoya *et al.* 1997, p. 138). Mormon tea (*Ephedra trifurca*), soap tree yucca, bear-grass (*Nolina texanum*), honey mesquite (*Prosopis glandulosa*), groundsel (*Senecidoo uglasii*), creosote bush (*Larrea tridentata*) and baccharis (*Baccharis thesoides*) make up 74 percent of the woody plants found in these home ranges in Mexico. Ground cover in this desert grassland habitat ranges from 28.9 to 69.5 percent on northern aplomado falcon territories and do not differ significantly between nesting and non-nesting territories ( $\bar{x}$  =49.9% versus 37.8%, respectively) (Montoya *et al.* 1997, p. 138).

In eastern Mexico, the northern aplomado falcon inhabits pastureland, fallow fields, and moist savannas (palm, oak, crescentia, and huisache) with scattered tall, bromeliad-laden trees; habitats are often created and maintained through human activities (Figure 2.4: agriculture and ranching) (Hector 1981, p. 19; Keddy-Hector 1988, p. 157).



Figure 2.2. Salty Prairie habitat in coastal Texas. *Photo credit: USFWS.*



Figure 2.3. Desert grassland habitat with soaptree yuccas in the Chihuahuan Desert. *Photo credit: Alberto Macías-Duarte and USFWS.*



Figure 2.4. Open pasture with tree fences in coastal Mexico. *Photo credit: Alberto Macías-Duarte.*

### *Breeding/Nesting Habitat*

#### Coastal Texas

Coastal Texas northern aplomado falcons display highest nest success in yuccas. They will also nest in shrubs (mesquite, huisache (*Acacia farnesiana*) and McCartney rose (*Rosa bracteata*), etc.), but yucca nests are more successful than shrub nests (Hunt *et al.* 2013, pp. 341-342). The Peregrine Fund has developed artificial nest structures that northern aplomado falcons readily use, currently rely upon, and in which the falcons show similar nest success levels as in yuccas (Hunt *et al.* 2013, p. 343).

Since northern aplomado falcons do not construct their own nests but rely on nests constructed by stick nest builders (Chihuahuan ravens (*Corvus cryptoleucus*), crows (*Corvus spp.*), crested caracaras, white-tailed hawks (*Geranoaetus albicaudatus*), red-tailed hawks, etc.), a healthy stick nest builder community is important for Coastal Texas northern aplomado falcon population nesting habitat. Casual observations suggest that raven (an important member of coastal Texas stick nest builder community) abundance was reduced by West Nile virus during this century's first decade (Hunt *et al.* 2013, p. 345). Mosquito-borne diseases such as West Nile are thought to be positively associated with human development (LaDeau *et al.* 2011, pp. 914-915). Predator abundance in woodland communities is thought to make woodlands and savannas unsuitable for northern aplomado falcon breeding habitat in coastal Texas. Human development is also thought to be positively related to woodland predator abundance. Therefore, protecting communities

inhabited by northern aplomado falcons from human development and woody encroachment in general is likely to be critical to maintaining the subspecies' breeding habitat in coastal Texas.

The "boom-and-bust" nature of the community's less diverse prey base, combined with migrating peregrine falcon (*Falco peregrinus*) abundance during northern aplomado falcon breeding territory establishment and nesting season onset, is thought to make South Padre Island's wind tidal flats unsuitable for northern aplomado falcon breeding habitat (P. Juergens and B. Mutch, pers. comm., May 2, 2023). Northern aplomado falcons prefer to breed in nearly treeless, yucca-studded, herbaceous-dominated communities, including irregularly flooded estuarine marsh (dominated by *Borrichia frutescens*, *Batis maritima*, *Monanthochloe littoralis*, glasswort (*Salicornia europaea*), etc.), salty prairie (dominated by Gulf cordgrass (*Spartina spartinae* and *Spartina patens*)), and deep-sand grasslands (dominated by seacoast bluestem (*Schizachyrium maritimum*), gulfdune paspalum (*Paspalum monostachyum*), etc.), probably in that order, owing to those respective communities' resistance to woody encroachment and development (J. McCabe, pers. comm., Feb. 13, 2023).



Figure 2.5. Yuccas and artificial nesting platforms that provide suitable nesting habitat in coastal Texas. Photo credit: USFWS.

### Chihuahuan Desert

Nesting habitat in the Chihuahuan Desert includes stick nests constructed by Swainson's hawks (*Buteo swainsoni*) or Chihuahuan ravens and is often located in soaptree yuccas in desert grasslands. In fact, Hector (1981, p. 6) points out that the distribution of the northern aplomado falcon in the U.S., west of the Pecos River, coincided fairly well with the distribution of the soaptree yucca. In southern New Mexico, land cover surrounding monitored nests is comprised of approximately 60 percent bare ground and 40 percent tobosa grasslands with widely scattered shrubs and succulents across most of the area. Dominant shrubs and succulents are mostly creosote bush, longleaf jointfir (*Ephedra trifurca*), and soaptree yucca. Littleleaf sumac (*Rhus microphylla*) is also present in the area (La Tierra 2020, p. 30). Swainson's hawk, crested

caracara, and Chihuahuan raven have historically been cited as important stick nest builders for the northern aplomado falcon in the U.S. (Bendire 1892, p. 307; Bent 1937, p. 96; USFWS 1990, p. 12; Hector 1981, p. 6; 1987, p. 388). Corvid abundance can be reduced by the West Nile virus in Chihuahuan Desert habitat as well as in Texas coastal habitat, also resulting in fewer potential nest structures (Hunt *et al.* 2013, p. 345).

Macías-Duarte *et al.* (2004, p. 1083) identified up to six habitat types associated with 19 nesting territories within two study areas (Tinaja Verde and El Sueco) in the Chihuahuan Deserts in the State of Chihuahua, Mexico: shrubland, tobosa swale, barren slope, gramma grassland, savanna, and yucca grassland. According to Macías-Duarte *et al.* (2004, pp. 1083-1084), shrublands are described as “areas with a high relative density of woody plants <1.5 m (5 ft) in height, principally *F. cernua*, *L. tridentata*, *E. trifurca*, *Mimosa* spp., and *Acacia* spp. Tobosa swales are open grasslands dominated by *H. mutica*. Barren slopes are grassland areas disturbed by grazing, with bare ground and rocky and shallow soils, usually on hills, the most common vegetation being *Dasyochloa pulchella* and *B. eriopoda*. Gramma grasslands are those in relatively good condition, with little bare ground and a very low density of woody plants (shrubs); the main grasses occurring in that habitat are *Bouteloua* spp., *Aristida* spp., *Muhlenbergia* spp., and *Chloris* spp. Savannas are grasslands with low to moderate densities of woody vegetation, the most common species being *P. glandulosa*, *Mimosa* spp., *E. trifurca*, *Acacia* spp., *C. ericoides*, and *Koeberlinia spinosa*. Yucca grasslands are savannas where yuccas, primarily *Yucca elata*, are the dominant woody vegetation.” Macías-Duarte *et al.* (2004, p. 1084) also noted that the average percentage of bare ground within 500 m (1,640 ft) of nests was 63.5 percent at Sueco and 38.8 percent at Tinaja Verde, and that open halophyte grasslands predominated in both study areas, interspersed with Chihuahuan Desert scrublands.



Figure 2.6. Mesquite tree with a northern aplomado falcon nest in the Chihuahuan Desert. *Photo credit: Alberto Macías-Duarte.*

### Tropical Lowlands

According to Hector (1981, p. 3; Keddy-Hector 1988, pp. 159-161), tall, small-crowned, sparsely distributed trees tend to characterize tropical lowland breeding habitat. Arboreal bromeliads, stick nest builders (crested caracaras, white-tailed kites (*Elanus leucurus*), roadside hawks (*Rupornis magnirostris*), brown jays (*Psilorhinus morio*), gray hawks (*Buteo plagiatus*), etc) and prey species are abundant in tropical lowlands breeding habitat. In Veracruz, examples of dominant trees in nesting habitat include huisache, Mexican palmetto (*Sabal Mexicana*), and caro caro (*Enterloblum cyclocarpum*) (Keddy-Hector 1988, p. 159). More recent observations suggest they use nests of gray hawks and common black hawks (*Buteogallus anthracinus*) on large epiphyte or clusters of bromeliaceae (*Tillandsia spp.* or *Catopsis spp.*), and on the flattened crowns of royal palms (*Roystonea regia*) (J. Gallardo, pers. comm., January 31, 2025). Land use practices, such as deforestation for grazing and agriculture, occur throughout the region and are thought to provide favorable habitat for the northern aplomado falcon (Cade 1982, p. 106). During such disturbance, it is important that sufficient trees are left to provide habitat for nesting structures constructed by stick nest building species (Hector 1981, pp. 77-78).



Figure 2.7. Palm trees in open pasture that provide suitable nesting habitat in coastal Mexico.  
Photo credit: Alberto Macías-Duarte.

### *Non-breeder/Floater Habitat*

Although the precise characteristics of habitat used by floaters (non-breeding individuals) cannot be described, it is likely that these individuals use a broader breadth of habitat than used by breeders. Ecological theory predicts that, if the habitat is vacant, floaters will occupy high quality habitat needed by breeding pairs (Hunt 1998, p. 191; see Breeding/Nesting Habitat above). However, if such habitat is unavailable, floaters likely occupy habitat less suitable for breeders. Observations suggests that these habitats can be closer in proximity to forested areas, which may increase predation risk and contain greater shrub densities which could impact hunting success (A. Macías-Duarte, T. Anderson, and A. Montoya, pers. comm., February 13, 2024). Hector (1981, pp. 58-78) reported that poorer habitat used by non-breeders was characterized by smaller trees with higher densities than at nesting sites, higher ground cover densities (although not

statistically significant), and lower density of birds but higher density of insects (although not statistically significant). However, Hector stated that lack of statistical significance does not preclude biological significance, and that further study was needed. In Chihuahua, non-breeding female falcons (likely floaters) have been observed in areas with greater shrub densities, apparently unsuitable for nesting (A. Macías-Duarte, pers. comm., May 5, 2024).

#### 2.3.4 Diet

The diet of northern aplomado falcons includes a wide array of birds (largely migratory), insects, mammals, and reptiles. Hunting methods include aerial prey capture of birds and insects but also include chasing prey and capturing it on the ground. Pairs often hunt cooperatively, especially when chasing birds (Hector 1986, p. 251). In coastal Texas, the northern aplomado falcon feeds primarily on small birds, but a variety of large insects, crustaceans, small reptiles, and mammals are also prey items (Perez 1995, p. 59-62). In the tropical lowlands, prey species include butterflies, dragonflies, groove-billed anis (*Crotophaga sulcirostris*), brown jays, great-tailed grackles (*Quiscalus mexicanus*), and white-collared seedeaters (*Sporophila torqueola*), among others (Hector 1981, pp. 23-25, p. 47, pp. 58-68). Avian prey comprised 94 percent of individual prey items found in and around nests in eastern Mexico and 35 percent of prey items seen captured during the same study, while insects comprised approximately 65 percent of prey items seen captured (Hector 1985, pp. 338-339). Earlier research from eastern Mexico determined that birds comprised 97 percent of prey biomass (Hector 1985, p. 339). Doves (*Zenaida* spp.), great-tailed grackles, groove-billed anis and yellow-billed cuckoos (*Coccyzus americanus*) comprised most of the biomass observed in this study. Northern aplomado falcons in the Chihuahuan Desert rely heavily on avian prey species (Macías-Duarte *et al.* 2004, pp. 1083-1086). For example, the most abundant avian prey species of northern aplomado falcons in Chihuahuan Desert grasslands in Mexico included meadowlarks (*Sturnella neglecta* and *S. magna*), common nighthawks (*Chordeiles minor*) and northern mockingbirds (*Mimus polyglottos*) (Montoya *et al.* 1997, p. 140). In a more recent study, the most frequent avian prey species' remains found near active northern aplomado falcon nests in the Chihuahuan Desert in Mexico were from mourning doves (*Zenaida macroura*), northern mockingbird, meadowlarks, and sparrows (*Emberizidae*) (Macías-Duarte *et al.* 2004, pp. 1085-1087)

Kleptoparasitism, or food piracy, has also been observed in northern aplomado falcons, primarily by taking prey from other avian predators (Clark and Wheeler 1987, p. 105; USFWS 1990, p. 11; Brown *et al.* 2003, p. 357; Perez 1995, p. 62). One study noted that most prey items pirated from other avian predators were mammals (Hector 1985, p. 341). While mammals are a very small part of the diet of northern aplomado falcons, piracy appears to account for most of the acquisition of mammalian prey (Brown *et al.* 2003, p. 358).

## 2.4 Genetics

Limited genetic research on the northern aplomado falcon provides inconclusive evidence of genetic structure. A genetic survey by Fleischer *et al.* (1998, pp. 3-5) using mtDNA and DNA microsatellite loci found little difference between the Chihuahua and Tropical Lowlands populations. A more recent genetic survey using 10 DNA microsatellite loci, however, suggests that the falcon population in Chihuahua has significantly lower genetic diversity compared to those in the Tropical Lowlands (Johnson and Stock 2017, p. 7) and forms a genetically distinct

cluster (Johnson and Stock 2017, p. 9). Nevertheless, the low sample sizes (individuals and loci) in both analyses prevent drawing strong conclusions on genetic structure of northern aplomado falcon populations.

The viability of small populations is compromised by loss of genetic diversity by inbreeding and drift. However, the reintroduced falcon population in coastal Texas currently shows no evidence of inbreeding and has similar levels of genetic diversity to the founder population of 27 individuals from eastern Mexico (Johnson *et al.* 2021, pp. 174-175). Gene flow between northern aplomado falcon populations and those of *F. f. femoralis* may occur in northern Central America, as the subspecies diagnosis of *F. femoralis* remains nebulous in the lack of genetic surveys (Keddy-Hector 2019, pp. 118-121).

### **3 DISTRIBUTION AND POPULATION TRENDS**

The northern aplomado falcon's historical distribution, its current distribution, and population trends are covered in this chapter. A review of the historical and current information on the range and distribution of the species is covered first, followed by a review of the trends of populations within the species' naturally occurring range.

#### **3.1 Historical Distribution**

It is difficult to identify where the nominate subspecies' range ends and the northern aplomado falcon's range begins in Central America.

Keddy-Hector (2019, p. 117) suggests the existence of a zone of intergradation connecting the nominate and northern subspecies along the Pacific slope, and a similar pattern occurring on the Caribbean slope, with southern Mexican *F. f. septentrionalis* averaging only slightly larger than *F. f. femoralis* from Central America and northern South America, but smaller than *F. f. septentrionalis* of the Chihuahuan Desert of Arizona, Chihuahua and Coahuila. The northern aplomado falcon historically ranged northward from this Central American intergradation zone. Its range extended from Chiapas along the Bay of Campeche to the northern Yucatan, and along the Mexican Gulf Coast up to Texas' mid-coast. It also extended across Mexico's central plateau up to trans-Pecos Texas, and southern New Mexico, and historically included southeastern Arizona (Figure 3.1). Northern aplomado falcon numbers declined through the early 1900s, and by the 1930s, the subspecies was uncommon (Ligon 1961, pp. 81-82; Hector 1987, p. 384; Meyer and Williams 2005, p. 352; USFWS 1990, p. 6). By midcentury, the northern aplomado falcon was absent from most of its range in the United States with very few sightings reported thereafter (Hector 1987, pp. 384-385; Meyer and Williams 2005, p. 352).

##### **3.1.1 Coastal Texas**

The first documented occurrence of the northern aplomado falcon in south Texas is known from 1876 by Dr. James C. Merrill, who noted them nesting in "*low Spanish bayonet growing in the Palo Alto Prairie about 7 miles from Fort Brown*" (Bendire 1892, p. 306). From 1890-1914, Frank Armstrong began a lucrative taxidermy business in Brownsville and collected 84 egg sets and 27 skins of the Aplomado from the Palo Alto Prairie area near Brownsville (Hector 1987, p. 383). Between the late 1800s to about 1930, other collectors found northern aplomado falcons in the Palo Alto Prairie area between Brownsville and Port Isabel (present day Bahia Grande area)

until the species became exceedingly rare thereafter (Hector 1987, p. 384). In fact, 67 percent of all U.S. egg and skin sets came from the Palo Alto Prairie (Hector 1987, p. 383). According to Oberholser (1974, p. 256) this area was the only site in south Texas known for regular breeding concentrations of the northern aplomado falcon.

The last documented nesting in Texas occurred in southern Brooks County in 1941 (Oberholser 1974, p. 257; Hector 1981, p. 124; Hector 1987, p. 383). Only a handful of sightings of the falcon in south Texas were documented after that time (Oberholser 1974, p. 257) until the first known modern nesting of the falcon was documented in 1995. This nest was discovered within the original Palo Alto Prairie and was due to successful reintroduction efforts by The Peregrine Fund that began there in 1993 (C. Perez, pers. comm., April 30, 2024)

### 3.1.2 Chihuahuan Desert

The northern aplomado falcon was known to inhabit Chihuahuan Desert grassland habitat in southern New Mexico, southeastern Arizona, west Texas, and Mexico (Keddy-Hector *et al.* 2020, *accessed* September 2023). However, by the 1930s this falcon had virtually disappeared from Chihuahuan Desert grassland habitat within its historical range in the U.S. as a result of livestock grazing impacts to vegetation and habitat conversion to farming (Hector 1981, p. 88). Many historical records of sightings and nesting are considered inadequate, and some specimen records may have been corrupted. This has resulted in some uncertainty about the historical range of northern aplomado falcons in the U.S (Keddy-Hector *et al.* 2020, *accessed* September 2023).

Between 1852-1952, only approximately 10 documented nesting attempts were recorded in the Chihuahuan Desert of New Mexico, Texas and Arizona at five localities: Fort Huachuca, Arizona; Deming and Jornada del Muerto, New Mexico; and the Davis Mountains and Midland, Texas. The last documented nesting of northern aplomado falcons in the United States prior to listing was reported in Chihuahuan Desert habitat southwest of Deming, Luna County, New Mexico, in 1952 (Ligon 1961, p. 82).

The northern aplomado falcon has been documented through sightings, collections or observed nesting in Chihuahuan Desert grassland habitat in Hidalgo, Grant, Luna, Doña Ana, Sierra, Socorro, Otero and Lea Counties of New Mexico; Cochise and Pima Counties of Arizona; and El Paso, Reeves, Brewster, Jeff Davis, Culberson, and Presidio Counties of west Texas (Hector 1987, pp. 381-383). It was considered extirpated from those locations as a breeding species by 1986 (USFWS 1986, pp. 6686-6690). In the Chihuahuan Desert of Mexico, the falcon was historically found in the States of Chihuahua, Sonora, Coahuila, Durango, Zacatecas, and San Luis Potosi (USFWS 1990, p. 4)

### 3.1.3 Tropical Lowlands

The historical known range of the northern aplomado falcon also included the States of Tamaulipas, Chiapas, Campeche, Tabasco, Coahuila, Sinaloa, Jalisco, Guerrero, Veracruz, Yucatan, and San Luis Potosi in Mexico, and the western coast of Guatemala (USFWS 1986, pp. 6686-6690).



Figure 3.1. Historical and current distribution of the northern aplomado falcon, suggested zone of intergradation between the nominate subspecies and northern subspecies, and distribution of the *F. f. femoralis* and *F. f. pichincae*. Note: *F. f. pichincae*, occurs in higher elevations of the Andes Mountains in parts of South America.

### 3.2 Current Distribution

Currently three populations of northern aplomado falcons are distributed across the subspecies historical range. These populations are geographically distinct from one another. The Coastal Texas population is located in south Texas along the Gulf Coast, the Chihuahuan Desert population is located within northern and central portions of the Chihuahuan Desert ecosystem within the U.S. and Mexico, and the Tropical Lowlands population is located within tropical ecosystems along portions of the Gulf and Pacific Coasts in Mexico (Figure 3.2). Below, we discuss the more refined distribution of the subspecies within each population.

### 3.2.1 Coastal Texas

The northern aplomado falcon has successfully been re-established in south Texas due to an aggressive recovery program involving captive breeding and re-introduction efforts. The first major northern aplomado falcon releases began in 1993 on Laguna Atascosa NWR and in 1996, a second release area began further north in the Texas Coastal Bend on Matagorda Island, part of Aransas NWR. From 1993-2004, a total of 843 young falcons were released from 21 sites in south Texas resulting in distinct breeding centers established near these release areas consisting of about 33 self-sustaining breeding pairs each year (Hunt *et al.* 2013, p. 335, pp. 341-344; The Peregrine Fund 2023c, p.2). In 2017, northern aplomado falcon breeding pairs reached a peak of 39 pairs before Hurricane Harvey struck the Texas Coastal Bend in August of that year. This resulted in the loss of 10 of the Texas mid-coast's 18 pairs (The Peregrine Fund 2021, p. 5). In the 5 years following Hurricane Harvey the number of breeding pairs in the Texas Mid-coast has increased to 11. However, during that same period, the number of breeding pairs along the Lower Laguna Madre del Norte has declined by 9 breeding pairs. So, the Coastal Texas population has declined from 39 breeding pairs in 2018 to 23 breeding pairs in 2022 (The Peregrine Fund 2022a, p. 3).

Currently, northern aplomado falcons are distributed across two major breeding areas along coastal Texas, one concentrated near Laguna Atascosa NWR and the other at Matagorda Island, a distance of approximately 140 miles. Therefore, in coastal Texas, the species currently ranges from Boca Chica to Matagorda Island, including Padre Island and San Jose Island. Northern aplomado falcons have dispersed between these two areas and interbred.

### 3.2.2 Chihuahuan Desert

The current breeding distribution of the northern aplomado falcon in the Chihuahuan Desert primarily occurs in the northern portions of the Mexican state of Chihuahua, and some breeding has been documented in southern New Mexico and west Texas. The current breeding status in west Texas is not well documented due to lack of formal surveys. However, incidental observations by landowners of at least two northern aplomado falcon pairs and evidence of nesting in the area indicate limited breeding is occurring (A. Montoya, pers. comm., February 6, 2024). During the 1990's, credible reports of northern aplomado falcons in New Mexico had been increasing (Meyer and Williams 2005, p. 352). From 2002 to 2012, reintroductions of captive-reared northern aplomado falcons into Chihuahuan Desert habitat in the U.S. were conducted. More specifically, these reintroductions occurred in west Texas between 2002 and 2012 and in southern New Mexico between 2006 and 2012 in efforts to restore populations in the Chihuahuan Desert. A total of 686 northern aplomado falcons were released from 11 sites in west Texas, and an additional 337 falcons were released across 10 sites in southern New Mexico (Hunt *et al.* 2013, p. 1, pp. 339-341; The Peregrine Fund 2023c, p.2); all released birds were banded. Following releases, three breeding attempts were observed in Sierra County on the Armendaris Ranch in southern New Mexico, with a total of five nesting attempts by 2014 (Sweikert and Phillips 2011, pp. 2-3). However, documented breeding efforts were successful in two of the five nesting attempts, and no nesting territories currently occur on the Armendaris Ranch (La Tierra 2020, p. 2). The failed reintroductions were attributed to coincidence of severe drought conditions, high rates of raptor predation, and lack of sufficient prey (Hunt *et al.* 2013, pp. 347-349).

As of 2022, there was one nesting pair of northern aplomado falcons in Luna County, New Mexico (La Tierra 2023, p. 36). This location in southwestern New Mexico at Simpson Draw, just west of Columbus, New Mexico, near the Mexican border, has been occupied intermittently by paired and individual northern aplomado falcons since 2000 (prior to releases) and has produced young, with a pair nesting twice in some years (La Tierra 2023, p. 10 Table 4). From 2001-2022, an average of 1.9 young were fledged per year, for years with nest attempts (La Tierra 2023, p. 10 Table 4) in Simpson Draw. Annual surveys conducted since then have documented continued occupancy of this territory but not successful nesting efforts in each of those years (La Tierra 2023, p. 37). As of 2023, a maximum of five northern aplomado falcons (a pair of breeding adults and their three fledged young) were documented in any given year in southern New Mexico at the Simpson Draw site (La Tierra 2023, p. 10, Table 4; p. 36-37). Anecdotal sightings have also been recorded in the Otero Mesa region on Fort Bliss and the White Sands Missile Range in southern New Mexico. In 2022, a few incidents of confirmed nesting activity or territorial defense behavior were documented in the Chihuahuan Desert historical range in New Mexico or the trans-Pecos region of west Texas. In 2022, one reported northern aplomado falcon sighting was made in western Dona Ana County (La Tierra 2023, p. 31). A nesting pair were sighted on a ranch near Van Horn Texas in 2020 (A. Montoya, pers. comm., February 6, 2024). Another pair were reported near Valentine, Texas in 2022, with the possibility that other adults had also been seen on the same ranch since 2018 (A. Montoya, pers. comm., February 6, 2024).

In the adjacent Chihuahuan Desert grasslands in Chihuahua, Mexico, two northern aplomado falcon breeding centers are known (Montoya *et al.* 1997, entire; Macías-Duarte *et al.* 2004, entire; Macías-Duarte *et al.* 2016, pp. 212-214). From 1996-2002, there were at least 35 territories monitored across these two breeding centers known as Sueco, near the municipality of Ahumada, and Tinaja Verde, near the municipality of Coyame (Macías-Duarte *et al.* 2004, pp. 1081-1084). In 1998-1999 surveys conducted in the northern portion of Chihuahua resulted in a total of 18 nests and a minimum of 79 northern aplomado falcons within a 100 km belt of the U.S.-Mexico Border (Young *et al.* 2004, p. 113; Meyer and Williams 2005, p. 355). However, beginning around 2006, much of the occupied northern aplomado falcon habitats at the Sueco site were lost due to conversion to irrigated farmland; declines were also documented at Tinaja Verde (Macías-Duarte *et al.* 2016, pp. 212-215). Population losses were so severe that from 2000 to 2014, the number of occupied territories dropped from 31 to only 3 and active breeding territories dropped from 24 to 2 at Sueco and Tinaja Verde (Macías-Duarte *et al.* 2016, p. 212). In fact, Macías-Duarte *et al.* (2016, p. 212) estimated there may be as few as 10 pairs remaining in central Chihuahua, posing serious threats to the continued existence of the northern aplomado falcon in the desert grasslands of Mexico.

The only known remaining population of wild, desert-breeding northern aplomado falcons nearest the U.S. occurs in the State of Chihuahua, Mexico (Macías-Duarte *et al.* 2016, pp. 211-212; Hunt *et al.* 2013, p. 347). This population in north-central Chihuahua was unknown until 1992 (Montoya 1995, p. 5; Montoya *et al.* 1997, p. 135).

### 3.2.3 Tropical Lowlands

Robust data on the distribution of the northern aplomado falcon in the tropical lowlands is lacking; however, it is thought to be distributed across three countries (Mexico, Guatemala, and

El Salvador) from Mexico’s Gulf and Pacific Coasts down to El Salvador (USFWS 1990, p. 4). Keddy-Hector (2019, p. 117) describes a zone of intergradation with the nominate subspecies along the Pacific and Caribbean coasts in Central America. In eastern and southern coastal Mexico, the focus area of this SSA, this falcon ranges along the Mexican Gulf coastal bend from southern Tamaulipas to the Yucatan Peninsula, and along the Pacific Slope from Guerrero to Chiapas. Limited information for northern aplomado falcons along the Pacific Slope was available, therefore, this area was excluded from analysis in the SSA. Limited surveys in 2021-2022 failed to document northern aplomado falcons on the Pacific Slope and documented one individual in the state of Merida (J. Gallardo, pers. comm., January 31, 2025).

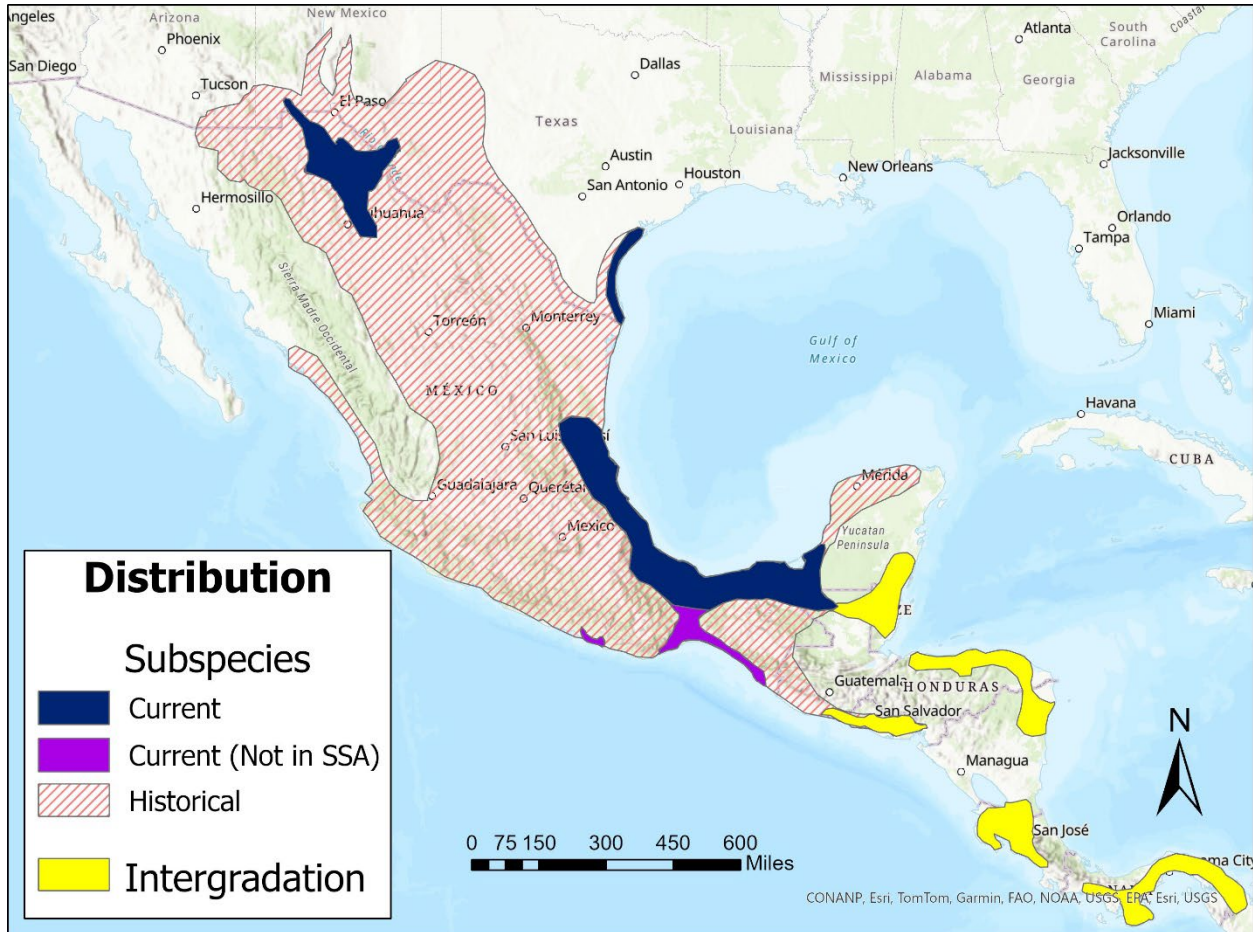


Figure 3.2. Historical and current distribution of the northern aplomado falcon and suggested zone of intergradation with the nominate subspecies. Note: Current distribution depicted in blue is analyzed in this SSA, current distribution in purple was excluded from analysis.

### 3.3 Population Trends

We describe three populations of northern aplomado falcon (Coastal Texas, Chihuahuan Desert, and Tropical Lowlands) throughout this SSA as a method of grouping the subspecies by biogeographic region. We based these distinctions upon apparent differences in landcover (USFWS 2024a, entire; J. McCabe *et al.* pers. comm., February 13, 2023) and on the lack of any data showing regular movement of northern aplomado falcons between these distinct areas.

Furthermore, we use nesting pairs as a surrogate for total abundance of individuals, as this species is monogamous and pairs can reasonably translate to reproductive effort. Pairs occupy territories annually, so these numbers provide a consistent measure of abundance over time. Using pairs will result in an inherently conservative population estimate. It will omit non-breeding adults or juveniles, but those demographic groups are considered to be fairly low in most falcon populations and not an important factor in estimating most raptor breeding populations (Hunt 1998, pp. 194-195). We consider a loss of breeding habitat, natural nesting structures, and prey availability to be major stressors to northern aplomado falcons. Therefore, we can infer that non-breeding adults (floaters) in any of the populations are not finding unprotected and productive breeding sites and thus are inconsequential to accurately estimating northern aplomado falcon population sizes.

### 3.3.1 Coastal Texas

Following The Peregrine Fund's restoration efforts, the Coastal Texas population achieved a high of 44 territorial pairs in 2005, before declining to 28 pairs by 2012 (The Peregrine Fund 2012, p. 9). During 2012-2013, some releases were conducted (n=87 individuals) which appeared to halt the population decline (The Peregrine Fund 2023c, p.1). The population then increased to 39 pairs by 2017 (The Peregrine Fund 2017, p. 3), but was quickly reduced to 26 pairs following Hurricane Harvey in August of 2017 (The Peregrine Fund 2019, p. 8). The population had regrown to 28 pairs in 2020, then declined by 2 pairs in 2021 (The Peregrine Fund 2021, p. 3). Currently, the population is comprised of 23 pairs (The Peregrine Fund 2022a, p. 3) (Figure 3.3).

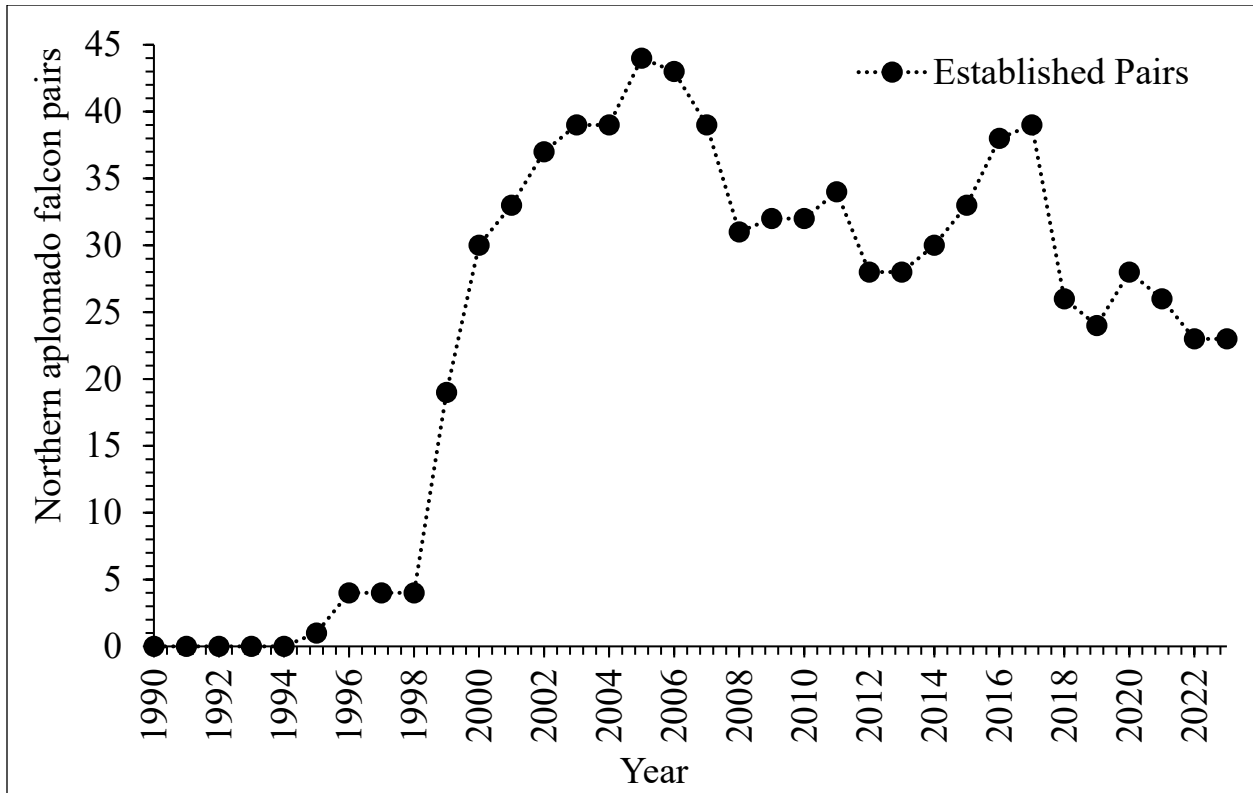


Figure 3.3. Established pairs of northern aplomado falcons in the Coastal Texas population over time. Data courtesy of Peregrine Fund.

### 3.3.2 Chihuahuan Desert

The population of northern aplomado falcons in the Chihuahuan Desert within the U.S. following listing in 1986 was augmented through the release of captive-bred northern aplomado falcons as part of the nonessential experimental population establishment effort under Section 10(j) of the ESA. During the release of captive bred northern aplomado falcons in west Texas and southern New Mexico from 2002 through 2012, survival and retention of released falcons varied from as low as 19 (2011) to as high as 138 (2005) individual falcons (Hunt *et al.* 2013, p. 345; USFWS 2014, pp. 25-28). High first-year mortality was attributed to predation, primarily by great horned owls and other raptors, but also possibly from starvation tied to low prey abundance aligned with severe drought years (Hunt *et al.* 2013, p. 347). Other causes of low retention include post-release natal dispersal movements to other areas (Macías-Duarte *et al.* 2021, p. 271).

The loss of desert grasslands to agricultural and urban development and the continued degradation of grasslands and the effects of drying climatic conditions on avian prey populations are currently limiting the recovery of the species in the Chihuahuan Desert and elsewhere (Hector 1987, pp. 387-388; Hunt *et al.* 2013, p. 349). Overgrazing and periods of drought have eliminated cover and food availability for grassland birds which are a major prey component of northern aplomado falcons. These conditions have also likely reduced other food sources such as insect prey abundance. As a result, northern aplomado falcons in the Chihuahuan Desert of the U.S. struggled to persist after reintroductions ended in 2012. Currently, there are one to three

known breeding pairs in the U.S. portion of the Chihuahuan Desert. The loss of habitat in Chihuahua, Mexico since 2006 to agricultural use has now reduced that portion of the Chihuahuan Desert population to an estimate of about 10 pairs (A. Macías-Duarte, pers. comm., May 5, 2024).

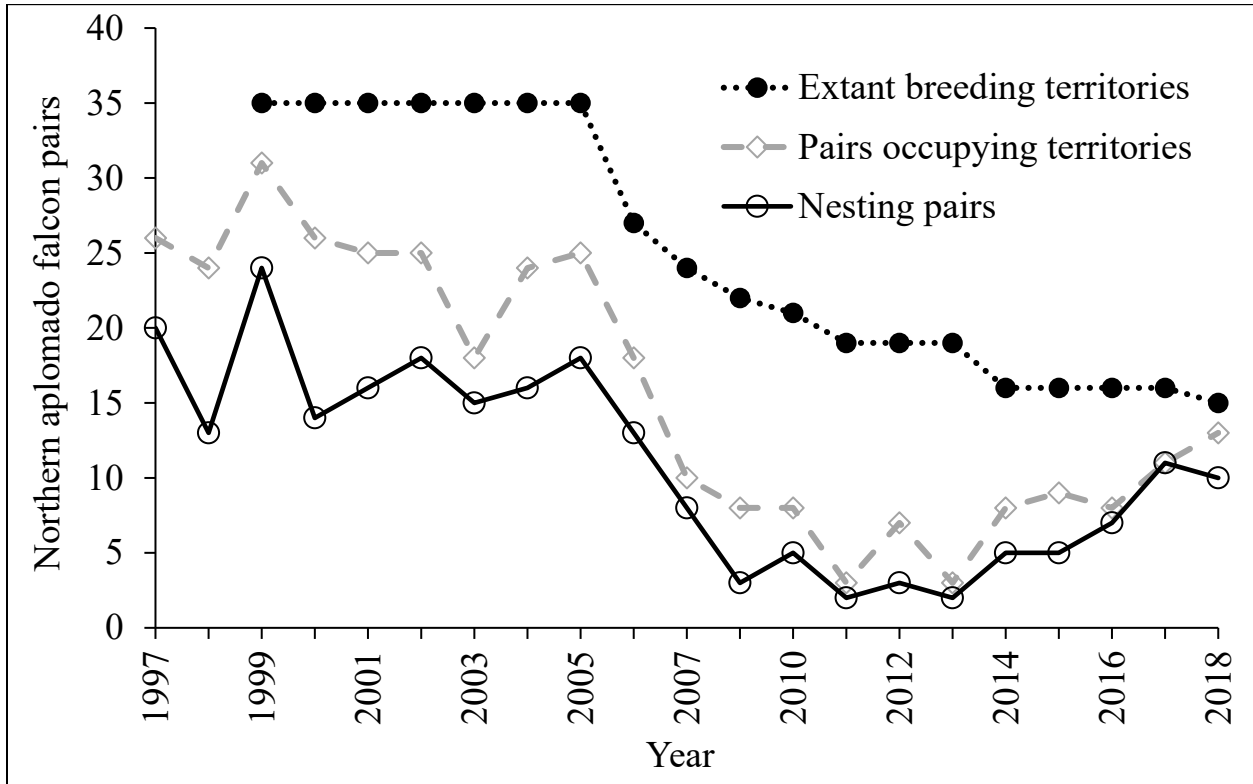


Figure 3.4. Extant breeding territories, pairs occupying territories and nesting pairs of northern aplomado falcons in the Chihuahuan Desert population in Chihuahua, Mexico over time. Data from 1997-2014 by Macías-Duarte et al. (2016). Data from 2015-2018 provided by Rodríguez-Salazar and Macías-Duarte.

### 3.3.3 Tropical Lowlands

There is some demographic data available for the tropical lowland population, but the species status there remains nebulous. The population seems secure as the species benefits from deforestation for agriculture and pasturelands in Latin America (Cade 1982, p. 106). Occupancy modeling on survey data suggests that occupancy of nesting territories remained constant from 2005 to 2015 in central Veracruz (A. Macías-Duarte, pers. comm., May 5, 2024), suggesting a stable population. Publicly provided eBird data, however, suggest negative abundance trends from 2007-2021 through nearly half of the Tropical Lowlands (Fink *et al.* 2022, accessed 2023; see Figure 3.5 below).

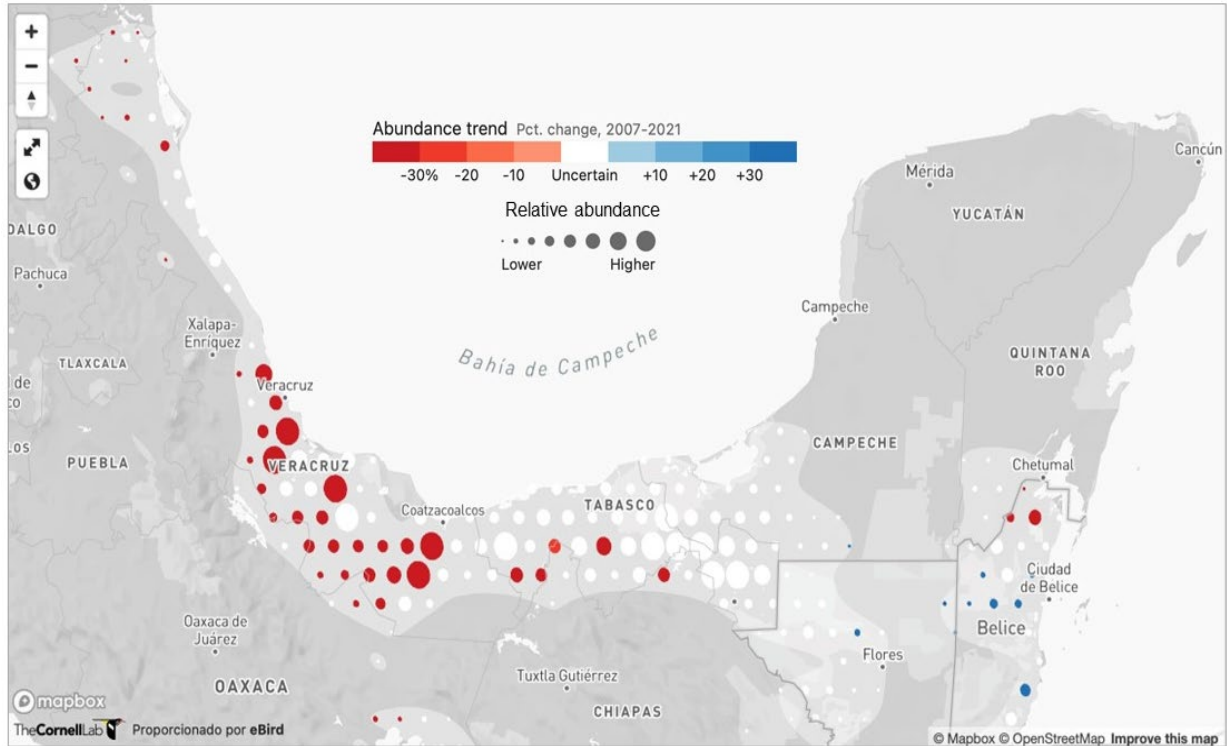


Figure 3.5. Change in estimated relative abundance from 2007 to 2021 for the Tropical Lowlands population (from eBird <https://science.ebird.org/en/status-and-trends/species/aplfal/trends-map>, accessed July 2023).

## 4 STRESSORS ON VIABILITY

In this chapter, the past, current, and future stressors that act on northern aplomado falcons directly, or on their needed resources, and that may affect the species' long-term viability are discussed (Figure 4.1). Current and potential future stressors, along with current and future expected distribution and abundance, inform species viability and, therefore, vulnerability to extinction. These stressors are organized by their sources: environmental changes and human development.

Habitat loss or alteration affects all stages of the northern aplomado falcon's life cycle, including nesting, roosting, and foraging. Given the substantial evidence of impacts from past and future habitat loss, this stressor is a major factor to be considered within our analysis of future species viability.

### 4.1 Stressors Included in Viability Analysis

#### 4.1.1 Environmental Changes

Projected changes in climate can have direct and indirect effects on northern aplomado falcons. These effects may be positive, negative, or neutral and they may change over time, depending on interactions with other variables such as changes in vegetation community structure and function, changes in land use and increases in avian disease outbreaks. Environmental changes are having evident effects in numerous aspects of avian biology including migration and nesting

phenology, geographic distribution, diseases, and food abundance (Jenouvrier 2013, p. 1; Pearce-Higgins and Green 2014, pp. 126-127). Heat waves, droughts, and high-intensity storms may cause direct and indirect impacts for northern aplomado falcons such as loss of nesting territories, habitat changes, and lack of prey availability. The impacts to avian prey species, nest building species and the northern aplomado itself from West Nile Virus could intensify, as the prevalence of zoonotic outbreaks of this disease in North America will likely increase in duration and intensity from these climate-related stressors (Paz 2015, p.2, pp. 5-6).

According to the Intergovernmental Panel on Climate Change (IPCC), it is virtually certain that there will be increases in the frequency of warm daily temperature extremes and decreases in cold extremes on a global scale. Heat waves will increase in length, frequency, and/or intensity. Droughts will likely intensify, and sea level will continue to rise (IPCC 2014, pp. 57-60; IPCC 2022, pp. 55-58). In the southwestern U.S. and northern Mexican desert grasslands, this trend has been shown to effect changes in vegetation community structure and composition via reduced precipitation and changes in the timing and intensity of monsoonal rainfall towards later in the growing season but with more frequent precipitation events of decreased magnitude. This change has favored shrub community expansion over grassland expansion as a result of increases in moisture availability during the prolonged growing season of shrubs such as creosote bush (*Larrea tridentata*) over grasses such as *Bouteloua* species (Petrie *et al.* 2015, pp. 1232-1233). This reduction in *Bouteloua* grasses and increase in shrub dominance can have a significant impact on overall vegetation community structure and biodiversity (Baez and Collins 2008, pp. 6-7). Losses of native perennial grasses and bare ground, when coupled with increases in annual cover, can increase wildfire risk and alter ecosystem function and value (Kleinhesselink *et al.* 2022, pp. 5-10). Dynamic changes in vegetation biodiversity could in turn negatively impact northern aplomado falcon prey populations (La Tierra 2023, pp. 38).

### *Drought*

The North American Southwest is projected to become more arid with more frequent multi-year droughts (Seager *et al.* 2007, p. 1181). Severe drought events in the desert habitat of the southwestern U.S. and northern Mexico have averaged around 19-20 years in duration (Williams *et al.* 2020, entire). Currently, this region is still experiencing a megadrought that has surpassed this average duration. Analyses of trends in soil-moisture anomalies has shown that this current drought may well exceed the last severe megadrought in the region that occurred in the late 1500s (Williams *et al.* 2020, p. 314). More recent analyses of these same data have extended the average duration of such severe droughts to 23 years, with some models even predicting durations of over 30 years in the future (Williams *et al.* 2022, p. 234).

Long-term drought and shrub encroachment in areas of Chihuahuan grasslands may be limiting recovery of the northern aplomado falcon (Hunt *et al.* 2013, p. 335). Warming and drying conditions in the Chihuahuan Desert may drive decreasing perennial cover and increasing cover of annual species, including the invasive Lehmann lovegrass (*Eragrostis lehmanniana*) and buffelgrass (*Pennisetum ciliare*) (Bodner and Robles 2017, pp. 6-7; Ludwig *et al.* 2017, pp. 55-57; Kleinhesselik *et al.* 2022, pp. 7-8). Changes to grassland structure and vegetative composition can result in shifts away from species that benefit native grassland birds. For example, between 2007 and 2015, species composition on Otero Mesa in Texas and New Mexico shifted from grama and muhlies (species that produce highly palatable seeds) to nine-awn

(feather) pappusgrass (*Enneapogon desvauxii*) and three-awns (*Aristida* spp.) (Gulf South Research Corporation and La Tierra Environmental Consulting 2016 as cited in La Tierra 2021, entire). Extensive drought conditions in the Chihuahuan Desert grasslands reduce seed and insect abundance essential to populations of migratory birds that are prey species, resulting in a decrease of prey for the northern aplomado falcon (Macías-Duarte *et al.* 2004, p. 1089; Macías-Duarte *et al.* 2018, p. 48). Prolonged drought conditions in the Chihuahuan Desert grasslands, compounded by heavy grazing pressure, could also result in a detrimental impact to habitat conditions that provide cover for migratory passerine birds that are prey species, negatively impacting their survival during winter (Macías-Duarte and Panjabi 2013, p. 147). Impacts to the abundance of migratory avian prey species can also be realized from drought and warmer conditions on their breeding range (Albright *et al.* 2010, entire). Nest initiation date is affected by prey abundance in the Chihuahuan Desert (Macías-Duarte *et al.* 2004, p. 1089), and decreases in prey due to drought will lead to a delayed nest initiation by northern aplomado falcons and greater risk of nest predation. The loss of prey base could cause food stress in northern aplomado falcons, making them more susceptible to disease or predation (Hunt *et al.* 2013, p. 347). Research has demonstrated a pattern of survival and retention of captive-bred northern aplomado falcons released in the Chihuahuan Desert grassland habitat of western Texas and southern New Mexico that is directly associated with average or above-average years of rainfall (Hunt *et al.* 2013, pp. 347-348) (Macías-Duarte *et al.* 2004, pp. 1082, 1088). Northern aplomado falcon populations in coastal Texas and the tropical lowlands are likely less impacted by drought relative to the Chihuahuan Desert population. The tropical lowlands and coastal Texas receive more precipitation and offer more prey during droughts than the Chihuahuan Desert does in an average year.

### *Sea Level Rise*

The warming of the Earth's atmosphere due to anthropogenic CO<sub>2</sub> emissions is projected to alter climatic regimes throughout the northern aplomado falcon's distribution, as well as produce an increase in sea level due to ice mass loss from Greenland to the Antarctic. There is an intermediate-high estimate of projected sea level rise of 0.51-0.79 m in the western Gulf coast (Sweet *et al.* 2022, p. 19). Rising seas are likely to result in lost northern aplomado falcon habitat in coastal Texas where northern aplomado falcons are primarily distributed near the coast in irregularly flooded estuarine marsh, salty prairie and deep-sand grasslands. The Peregrine Fund's coarse interpretation of the potential sea level rise effects found that with the Intermediate-High scenario, the amount of suitable habitat most likely would sustain a population of 60 pairs (J. McCabe *et al.* pers. comm., February 13, 2023).

While no such analysis has been conducted for the northern aplomado falcon population in the tropical lowlands, it is reasonable to suppose that the tropical lowlands are also likely to lose habitat to rising seas. It is also reasonable to suppose that because the tropical lowland population is distributed further inland than the population in coastal Texas, the tropical lowland population is more resilient to rising seas than the Coastal Texas population.

### *Tropical Storm/Hurricane*

The coastal Texas population's sharp decline during Hurricane Harvey and subsequent slow recovery indicates its vulnerability to hurricanes is due to its small size and localized, near-coast

distribution. The population will likely need to achieve greater size and more widespread distribution to be more resilient to hurricanes. The tropical lowlands population is assumed to be large and widespread enough to be more resilient to hurricanes, but this assumption bears further scrutiny.

Environmental changes are expected to increase the proportion of high intensity hurricanes, which can increase the potential for impacts to northern aplomado falcon populations in coastal Texas and in the tropical lowlands. Although northern aplomado falcons are likely capable of moving away from hurricanes that make landfall during the day, they may be more impacted by hurricanes that make landfall during the night when they are roosting. For example, Hurricane Harvey, which made landfall at night, resulted in mortality of 25 percent of breeding birds in the landfall zone. The northern aplomado falcon PVA modeled impacts from catastrophic events at once every 30 years (current (.033) annual risk), once every 15 years (.15 annual risk) and once every 10 years (.10 annual risk) which coincides with predicted increases in severe hurricanes for coastal populations. Based on data from 1886 through 2002, the frequency of Category 4 and 5 hurricanes along the Gulf Coast has been approximately one every 30 years (Blake *et al.* 2011, p. 26). Modeling by the National Hurricane Center for Atmospheric Research indicates a 2- to 4.5-fold increase in the frequency of major hurricanes going forward (Bruyere *et al.* 2017, p. 69). It is expected that this increased hurricane risk will, in turn, increase adult breeder mortality. Increased potential for severe hurricanes may also increase habitat loss. For example, in Louisiana, more than 300 square miles of coastal marshland was lost from 2005-2008 following hurricanes Katrina, Rita, Gustav and Ike (CPRAL 2017, p. ES-2). As the incidence of Category 4 and 5 hurricanes increases, additional habitat loss is likely to occur along the Gulf Coast.

### *Fire Regime Changes*

Fire is a natural effector of Chihuahuan Desert grassland community structure (Humphrey 1974, pp. 388-93). Naturally ignited grassland fires would normally occur between the spring and late-summer growing seasons in the Chihuahuan Desert, prior to the increased precipitation during the monsoon season (July-September) (Ladwig *et al.* 2014, p. 622). Natural fire regimes in the Chihuahuan Desert grasslands as well as the rest of the southwestern U.S. will likely be altered because of changing climatic conditions (Abatzoglou and Kolden 2011, p. 471). Burning desert grassland vegetation outside of this normal period will not likely influence plant community structure (Ladwig *et al.* 2014, p. 626). However, the synergistic effect of fire on a plant community during a prolonged drought can result in a changed plant community as well as slow the overall recovery of the plant community for years (Ladwig *et al.* 2014, p. 626). This reduction in grassland vegetation cover and species composition could result in a decrease in prey availability for the northern aplomado falcon, as avian and small mammal prey species that depend upon this vegetation for cover and food decrease in abundance (Hunt *et al.* 2013, p. 344).

Many invasive plant species can be increased in distribution and dominance in the Chihuahuan Desert grassland from the effects of fire (Brooks and Pyke 2002, p. 8). This can result in a significant decrease in native plant species such as black grama (*Bouteloua eriopoda*) and various dropseed (*Sporobolus*) species that provide important cover and food for ground nesting and foraging prey species. Invasive grasses, such as cheatgrass or Lehmann lovegrass, can result in increased fire intensity, since these grasses provide more fuel matter than native grasses. These invasive grasses also thrive in post-fire landscapes, allowing them to dominate over native

species. (Brooks and Pyke 2002, p. 5). A study in Arizona found that sites dominated by native grasses supported a greater variety and abundance of animals, including birds, than areas with exotic lovegrasses (Bock et al. 1986, p. 462). Therefore, it is possible that an increase in these invasive grasses could contribute to a decrease in available prey. Additionally, grasslands in the Chihuahuan Desert are often overgrazed, which does not leave much fuel matter for fires to burn (Brooks and Pyke 2002, p. 6). Overall, the Chihuahuan Desert will see an altered fire regime that can impact prey availability (Bock and Block 2005, pp. 4-8).

While fire can be a stressor in coastal Texas by consuming nests and killing northern aplomado falcon nestlings, fire is also vital to conserving northern aplomado falcon habitat. There are no documented instances of fires consuming nests or directly killing northern aplomado falcons in coastal Texas, but reduced fire frequency is one of the greatest underlying causes of habitat loss to woody encroachment in coastal Texas, tipping the balance in favor of northern aplomado falcon predators in areas where brush and trees have invaded coastal prairie, deep-sand grasslands and gulf cordgrass-dominated prairie. *Borrichia* or shoregrass (*Monanthochloe littoralis*) dominated communities typically lacks sufficient fine fuels to carry fires; thus, fire tends not to be a stressor in such communities.

Fire serves as an important tool in mitigating shrubland encroachment (see Section 4.1.2 for *Woody Encroachment*). A decrease in fire frequency could result in increased woody encroachment, which could negatively affect habitat in the Chihuahuan Desert and Coastal Texas populations. In contrast, managed fire in the tropical lowlands creates and maintains open fields which are used by northern aplomado falcons. Although considered beneficial for maintaining habitat, burns occur through the northern aplomado falcons reproductive and dispersal seasons and nests have been lost to managed fire (J. Gallardo, pers. comm., January 31, 2025). Thus, altered fire regimes may be a stressor for northern aplomado falcon populations in the Chihuahuan Desert grasslands and coastal Texas, but may not be a population-level stressor for the tropical lowlands population where it is generally considered beneficial. Additional research on the impacts of managed fire on the species in the tropical lowlands of Mexico is needed.

### *Disease*

The frequency and magnitude of the threat that diseases pose to northern aplomado falcon populations is unclear. The threat to northern aplomado falcons from disease could be through direct mortality, or a reduction in prey availability from avian pathogens. For avian prey that are migratory, exposure to disease can occur in breeding or wintering range.

Northern aplomado falcons are known to be susceptible to disease. In 1996, an Adenovirus outbreak infected a large number (72 of 110) of young (9 to 35 days old) captive northern aplomado falcons, resulting in the death of 62 individuals less than 35 days old (Schrenzel et al. 2005, p. 3403). Newcastle disease, an infectious and highly contagious Avulavirus that causes mortality of domestic poultry worldwide, is endemic in Mexico and has been detected in the wild in the United States; reservoir species for this disease include the *Columbidae* family (pigeons and doves), and double-crested cormorants (*Phalacrocorax auratus*: Brown and Bevins 2017, pp. 1-4). Multiple falcon species, gyrfalcons (*Falco rusticolus*), saker falcons (*Falco cherrug*), peregrine falcons (*Falco peregrinus*), and lanner falcons (*Falco biarmicus*) as well as hybrid falcons, (gyr-saker falcons and gyr-peregrine falcons), were found to be equally susceptible to

Newcastle disease (Samour 2014, p. 2). Transmission can occur through contaminated feces, respiratory excretions and consumption of contaminated prey (Samour 2014, p. 2). In falcons, clinical signs of infection include paresis (leg and wing), torticollis, circling, tremors, absence of interactive and preening activity, loss of appetite, regurgitation, metallic-green urates, and can progress to death (Samour 2014, p. 3). Newcastle disease may be of concern to northern aplomado falcons in Mexico where prey species (e.g., doves) are reservoirs for the disease and occur in northern aplomado falcon populated areas.

There has been some concern that current northern aplomado falcon population status may have been affected by outbreaks of West Nile Virus in the early part of the 21<sup>st</sup> century (Hunt *et al.* 2013, p. 347). To date, only one confirmed incident of direct mortality to a northern aplomado falcon from West Nile Virus occurred in 2007 at a release site in west Texas during the reintroduction efforts between 2002 and 2013 (The Peregrine Fund 2007, p. 50.) This was at the height of the West Nile Virus outbreak in Texas. There is a positive relationship between human development and West Nile Virus transmission (Kilpatrick 2011, p. 12). The effects of changing climatic conditions have been shown to potentially amplify the impacts of avian pathogens and epizootic events (Sachan and Singh 2010, entire). Future West Nile Virus epizootic events in North America can be expected to be positively correlated with increased temperatures (Paz 2015, p. 5). This could result in a decrease in future nesting platforms, as West Nile Virus is known to have high mortality rates in corvids such as crows and ravens (McLean 2006, entire; Nemeth *et al.* 2007, entire). An overall decrease in avian prey species resulting from epizootic events such as West Nile Virus or avian influenza outbreaks could result in starvation or reproductive failure across the northern aplomado falcon’s range. Such outbreaks could occur on seasonal ranges of avian migratory prey species, increasing the risk of impacts to prey abundance.

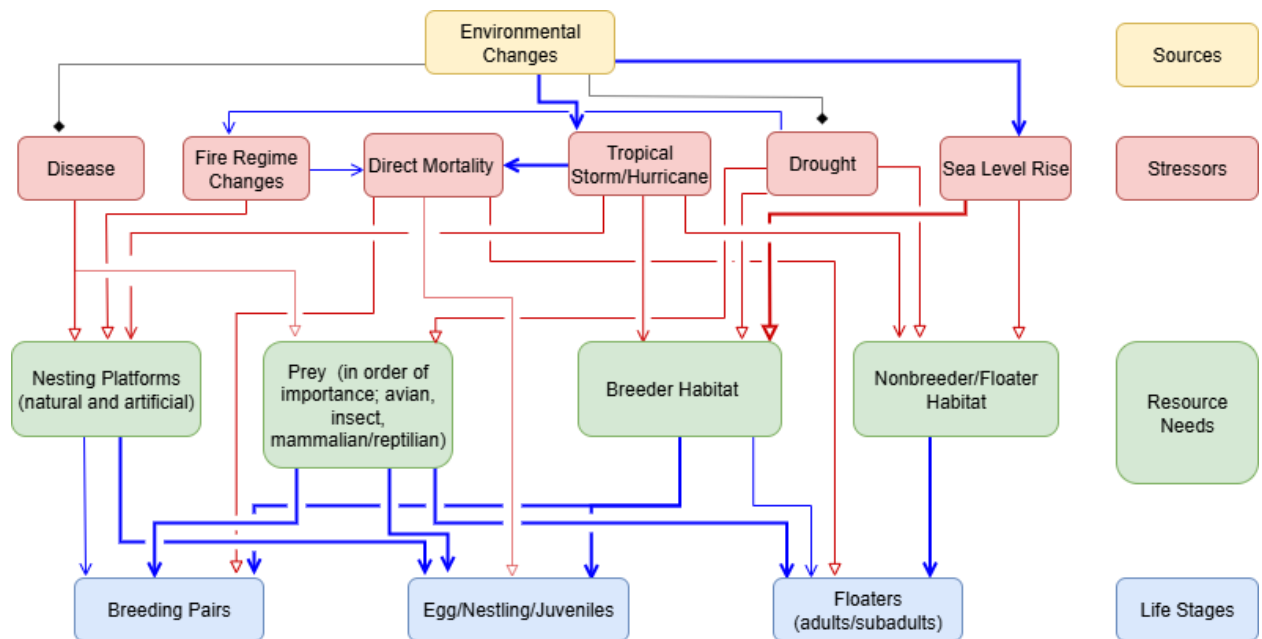


Figure 4.1. Conceptual Model illustrating the relationship between environmental changes and resulting stressors to both habitat and resources essential to northern aplomado falcon viability. Note that arrow colors correspond to positive (blue, line arrow) or negative (red, open arrow)

relationships; a black arrow, closed diamond, indicates that the relationship may be either positive or negative.

#### 4.1.2 Human Development

##### *Land Conversion*

Habitat conversion from desert grassland to urban, commercial, agricultural or residential use will generally result in a complete loss of functional habitat, while habitat fragmentation may leave areas of desert grassland intact but reduce their value as breeding or foraging habitat for falcons, as they will generally avoid or minimize the use of fragmented habitat in favor of larger tracts of intact desert grassland habitat.

It is estimated that approximately 758,313 acres (ac) out of 46,362,655 ac (2%) of total Chihuahuan Desert grassland habitat in the U.S. was lost to human development between 1986 and 2020 (Table 4.1). This resulted in an average annual loss of over 22,000 ac per year over this 34-year period (USFWS 2024b, pp. 4-5). This overall rate of development has resulted in approximately one third of the Chihuahuan Desert habitat in the U.S. being highly impacted by direct loss or fragmentation, as well as habitat modification, especially from energy development (McClung *et al.* 2019, p. 1954).

Future modeling indicates that over 2,100,000 additional acres of Chihuahuan Desert grassland habitat in the U.S. will be lost to human development by 2080 (Table 4.2). This is projected to result in the additional loss of 5 percent of this habitat in the U.S. over the next 60 years (USFWS 2024b, p. 5-7). Primarily, this will be from urban, suburban and rural industrial and residential land development and not from conversion to agricultural use.

Historically, non-renewable energy development for oil and gas extraction were the dominant forms of energy development in this habitat. The persistence of oil and gas development in the Permian Basin of southern New Mexico and west Texas will continue to modify Chihuahuan Desert grassland habitat through the development of infrastructure and roads associated with this industry. The most recent report on future activities on U.S. Bureau of Land Management (BLM) and private lands in the Chihuahuan Desert grasslands of southern New Mexico and west Texas indicate that there is still a moderate potential for future well development, primarily in the habitat along the New Mexico and Texas border in southern Otero County New Mexico through 2035 (Glover 2017, pp. 4-9). This level of activity could deter future northern aplomado falcon territories in these active extraction areas as well as reduce avian prey species richness and relative abundance through habitat degradation and avoidance of roads and infrastructure (Gutzwiller and Barrow 2003, p. 235).

Renewable energy development is increasing in Chihuahuan Desert habitat (BLM 2018, entire). Solar energy development has been, and will continue to be, highly concentrated in the desert southwest of the U.S. (Katzner *et al.* 2013, p. 368). In the Chihuahuan Desert of the U.S., solar energy development has the greatest potential in southwestern New Mexico, while non-renewable oil and gas development continues to impact southeastern New Mexico and west Texas (McClung *et al.* 2019, pp. 1956-1957, Figs. 3,4). Renewable energy development is not considered to have the same degree of impact to desert habitat as traditional non-renewable

energy development but could be developed in areas of the desert already impacted by non-renewable energy instead of undeveloped habitat (McClung *et al.* 2019, p. 1956).

The low human population in the Mexican portion of the Chihuahuan Desert region could offer the possibility of effective protection since it is considered to have a lower potential for future residential or commercial development in support of any human population growth (McClung *et al.* 2019, p. 1958). However, habitat conversion in the Mexican portion of the Chihuahuan Desert has occurred between 1986 and 2021, primarily from conversion of desert grassland habitat to irrigated agriculture (USFWS 2024c, entire). This conversion comprises a high portion of historical nesting territories (monitored since 1996) and their vicinity in the Valles Centrales region of Chihuahua, Mexico (A. Macías-Duarte, pers. comm., May 5, 2024; Macías-Duarte *et al.* 2016, p. 214). Agricultural development of desert grassland habitat within the Sueco and Tinaja Verde areas of the State of Chihuahua that support occupied nesting areas has resulted in the loss of approximately 557,000 acres of high, moderate and low habitat value between 1986 (8,021,357 ac) and 2021(7,464,153 ac). This is approximately 7 percent of habitat once known to be occupied by northern aplomado falcons, primarily resulting from an estimated 442 percent increase in agricultural development in the Chihuahuan Desert of Mexico since 1986 (USFWS 2024c, p. 9; A. Macías-Duarte, pers. comm., May 5, 2024). The Janos Biosphere Reserve was created in 2009 to protect and conserve more than 200,000 ha of desert grassland in northwestern Chihuahua (Comisión Nacional de Áreas Naturales Protegidas, 2013, p. 17), where northern aplomado falcons are known to occur (eBird, A. Macías-Duarte, pers. comm., May 5, 2024). However, cropland expansion remains a threat for grasslands around the biosphere reserve in spite of their protection status (Hruska 2020, p. 282). Although there are other protected areas of Chihuahuan Desert in the Mexican states of Chihuahua and Coahuila (Cañón de Santa Elena and Maderas del Carmen Protected Areas), it is not certain that these areas would have the habitat conditions necessary to support northern aplomado falcons. There is insufficient data available to model the potential loss of habitat to future conversions in the state of Chihuahua, Mexico.

Livestock grazing, while not directly resulting in a loss of northern aplomado falcon habitat, has historically modified habitat such that it has had a significant impact on the ability of prey species to be sustained at levels required for northern aplomado falcon to establish territories and successfully breed in Chihuahuan Desert grassland habitat (Hector 1987, pp. 387-388; USFWS 1990, p. 8). Intense grazing has resulted in significant levels of woody vegetation encroachment into Chihuahuan Desert grassland habitat that impairs the ability for northern aplomado falcons to effectively hunt. This has also resulted in barren habitat with poor overall vegetation structure in some locations. Grazing impacts to vegetation community structure continues to be a risk factor to the recovery of Chihuahuan Desert grassland habitat in southern New Mexico and west Texas (USFWS 1990, pp. 34-35; Zimmer 1995, pp. 50-56; Meyer and Williams 2005, p. 355). Grazing livestock may also be a source of disturbance for nesting falcons. In southern New Mexico, falcons nested in the same yucca multiple years and were successful in the years without livestock in the pasture and failed the years livestock were present. Evidence, such as signs of livestock rubbing on the nest yucca, indicate there may be an association between livestock and northern aplomado falcon nest failures in this area (La Tierra 2023, pp. 15-16).

Human development is proceeding rapidly in coastal Texas and is a primary threat to northern aplomado falcon habitat for this population. Between 1986 and 2020, 14 percent of coastal Texas

grass and shrub vegetation was lost to development, primarily through agricultural conversion (8%) and urban development (5%), with 1 percent lost to modification from grazing impacts resulting in barren or disturbed ground (Table 4.3) (USFWS 2024b, pp. 3-5).

Projection into the future suggests that over 104,000 additional acres of coastal Texas grass and shrub habitat in the U.S. will be lost to human development by 2080. This is projected to result in the additional loss of 20 percent of this habitat over the next 60 years (Table 4.4) (USFWS 2024b, pp. 5-7). According to the data sets used in this analysis, this will primarily continue to shift to loss from urban, suburban and rural land development as opposed to agricultural conversion (USFWS 2024b, entire).

Habitat fragmentation in the Chihuahuan Desert from roads and infrastructure development can negatively affect avian species richness and relative abundance (Gutzwiller and Barrow 2003, pp. 235-236). This can impact the ability of northern aplomado falcons to establish breeding territories and successfully nest resulting from a decrease in available avian prey. An increased matrix of roads and new infrastructure in the Chihuahuan Desert could also result in an increase in direct mortality to northern aplomado falcons from collisions with vehicles and infrastructure (Hager 2009, p. 211) especially while pursuing avian prey at high speeds (Keddy-Hector *et al.* 2020, accessed September 2023). Other future uses could include an expansion of commercial spaceflight development as exemplified by the construction and use of Spaceport America in Sierra County, New Mexico, near the location of the northern aplomado falcon releases conducted between 2002 and 2013. This could result in a loss of potential habitat as well as an increased risk of mortality from potential collisions with spacecraft during takeoff and landing. Developments of this type will result in a permanent loss of functional habitat through the removal of physical and biological features that the falcon needs for shelter, feeding and successfully reproducing.

In coastal Texas, roads and drainage ditches associated with human development effectively suppress processes (e.g., fire and coastal flooding) that are vital to maintaining northern aplomado falcon habitat. Expanding road and drainage ditch networks facilitate woody encroachment into grasslands and irregularly flooded estuarine marshes, making them unsuitable for northern aplomado falcons long before the habitat is cleared for construction.

Land conversion is not considered a stressor for falcons in the tropical lowlands. Conversion typically converts forest into grasslands for grazing or into agricultural fields. Veracruz is the largest sugar cane producing state in Mexico, accounting for approximately 40 percent of its total production, followed by San Luis Potosi (USDA and GAIN 2022, pp. 2-3; 2024 pp. 3 and 5). This conversion could benefit northern aplomado falcons in this habitat type by increasing suitable habitat (Keddy-Hector *et al.* 2020, accessed September 2023). However, sugar cane harvesting occurs from late-October to June and burning of fields prior to harvest is still a common practice (Geo-Mexico 2011, accessed April 2025). Burning during northern aplomado falcon nesting could result in the loss of nests, eggs, and hatchlings if the managed fire advances into nesting trees. Burned nests have been documented, however, the timing of the burn was not known (J. Gallardo, pers. comm., January 31, 2025). The length of the harvest season suggests that any impacts from burning of sugar cane fields may have local rather than population level impacts; it is not known if timing of burning in local areas is consistent or varies over-time.

Table 4.1- Chihuahuan Desert vegetation loss to human impacts in U.S from 1986 to 2020

Type of Loss	Acres
Urban Development	193,681
Agricultural Conversion	361,014
Barren-Disturbed Land	203,618
<b>Total current loss</b>	<b>758,313</b>

Table 4.2- Projected Chihuahuan Desert grass and shrub vegetation loss to human impacts in U.S. from 2020 to 2080

Type of Loss	Acres
Rural Development	1,664,655
Suburban Development	149,332
Urban Development	176,501
Industrial-Commercial Development	36,452
Transportation	82,734
Agricultural Conversion	1,994
<b>Total projected future loss</b>	<b>2,111,669</b>

Table 4.3- Coastal Texas grass and shrub vegetation loss to human impacts in U.S. between 1986-2020

Type of Loss	Acres
Urban Development	24,828
Agriculture	39,963
Barren/Disturbed	6,997
<b>Total current loss</b>	<b>71,789</b>

Table 4.4- Projected coastal Texas grass and shrub vegetation loss to human impacts in U.S. from 2020 through 2080

Type of Loss	Acres
Rural Development	59,699
Suburban Development	13,540
Urban Development	8,169
Industrial-Commercial Development	3,663
Transportation	1,229
Agricultural Conversion	17,924
<b>Total projected future loss</b>	<b>104,224</b>

### Contaminants

When the northern aplomado falcon was first listed as endangered, environmental contaminants were listed among the threats to the subspecies existence (USFWS 1986, pp. 6686-6690). The

role of organochlorine (OC) pesticides in nest failure from eggshell thinning, as occurred in other falcon species such as the peregrine falcon, was of particular interest. Levels of OC compounds, primarily DDE [1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene], were elevated in northern Chihuahua, Mexico, but did not seem to negatively affect reproductive success in a population studied there (Mora *et al.* 2008, pp. 48-49). Similarly, levels of OC compounds have generally decreased in the U.S. since listing in 1986, but some prey species still show higher levels of OC in the Lower Rio Grande Valley than others (Mora *et al.* 2008, p. 45). Northern aplomado falcon eggs from coastal Texas still had detectable levels of OC compounds, but these did not seem to have a negative effect on reproductive success (Mora *et al.* 2008, p. 49). While concern over eggshell thinning from OCs was seen as a major threat to northern aplomado falcon breeding success when listed, the reduction of levels in coastal Texas and in some areas of Chihuahua, Mexico since then has possibly decreased the level of threat of these compounds to the northern aplomado falcon (Mora *et al.* 2008, p. 49; Mora *et al.* 2011, p. 3435). Continued monitoring of these compounds in both the U.S. and Mexico will be necessary to determine if any unauthorized use of these pesticides results in further threats to northern aplomado falcons.

Other contaminants of potential concern include inorganic trace elements such as arsenic (As), barium (Ba), copper (Cu), mercury (Hg), manganese (Mn), lead (Pb), selenium (Se), strontium (Sr), and zinc (Zn). Levels of all trace elements were not considered high enough to be of concern to northern aplomado falcons, with the possible exception of mercury. Levels of polychlorinated biphenyls (PCBs) are also considered to be below levels of concern and have not varied much from levels measured in northern aplomado falcon eggs in the mid-1990s (Mora *et al.* 2008, p. 49). Recent tissue sample analyses from northern aplomado falcons in Mexico found no evidence of elevated contaminant levels (USFWS 2014, p. 23; Mora *et al.* 2011, p. 3437).

### *Woody Encroachment*

In the United States, woody encroachment into Chihuahuan Desert grassland habitat, primarily resulting from historical livestock grazing practices, is considered to be a significant threat to northern aplomado falcons in that habitat (Truett 2002, pp. 385-386; Meyer and Williams 2005, pp. 352-355). Increased woody vegetation reduces hunting effectiveness, since the northern aplomado falcon is primarily an open habitat hunter (Keddy-Hector *et al.* 2020, accessed September 2023; Hector 1986, p. 163). Woody encroachment can also increase habitat conditions that support predators in this habitat type, especially for great horned owls (Hunt *et al.* 2013, p. 346). Compared to the U.S., woody plant encroachment into desert grassland habitats may have occurred more recently in Chihuahua, Mexico allowing the persistence of northern aplomado falcons in Mexico after its extirpation in the United States (Macías-Duarte *et al.* 2004, p. 1090).

Woody encroachment is a current threat to northern aplomado falcon habitat in coastal Texas. Reduced fire and flooding frequency has resulted in an expansion of woody vegetation into coastal grasslands and marshes that once provided habitat for northern aplomado falcon. Northern aplomado falcons avoid areas with trees, particularly live oak mottes. Woodlands are suboptimal hunting areas for falcons and are frequently inhabited by animals that prey on northern aplomado falcons (e.g., great horned owl).

Woody plant encroachment occurs as part of vegetational succession in abandoned pastures and cropland in the tropical lowlands of eastern Mexico. This secondary succession produces thornscrubs that eliminate the spacing needed by northern aplomado falcons for hunting prey, and it may have caused the abandonment of historical nesting territories in Veracruz (Keddy-Hector *et al.* 2020, accessed September 2023; A. Macías-Duarte, pers. comm., May 5, 2024).

### *Direct Mortality*

#### Predation

The threat posed by northern aplomado falcon predators tends to be greatest in woodlands, and in areas lacking yuccas or artificial nest structures where northern aplomado falcons may nest in shrubs or on the ground. Woodlands are usually inhabited by great horned owls and other species which prey on northern aplomado falcons. Northern aplomado falcon nests located in shrubs and on the ground are much more vulnerable to predators, and much less successful than nests in yuccas and artificial structures (Brown and Collopy 2008, entire).

In the Chihuahuan Desert, the most imminent threats to northern aplomado falcon nests involve avian predators; including the golden eagle (*Aquila chrysaetos*), Swainson's hawk and Chihuahuan raven (La Tierra 2019, pg. 33). Other potential avian predators include prairie falcon (*Falco mexicanus*), Northern harrier (*Circus hudsonius*), golden eagle, ferruginous hawk (*Buteo regalis*), and red-tailed hawk (La Tierra 2019, pg. 6). Mammalian predators also pose a threat; including mountain lion (*Puma concolor*), bobcat, fox (*Vulpes* spp.), and coyote; though disturbance from terrestrial vertebrates can be deterred by the height of the nest (La Tierra 2019, pg. 33).

In addition, in the tropical lowlands of Mexico, a black spiny-tailed iguana (*Ctenosaura similis*) was observed eating a northern aplomado falcon egg on a royal palm. Although a single observation, it and the highly abundant crested caracara, a diurnal raptor, could be of predatory concern for the Tropical Lowland Population (J. Gallardo pers. comm. 2025).

#### Shooting

The frequency and magnitude of the threat posed to a northern aplomado falcon population from shooting and other forms of human persecution is unknown. While unconfirmed, there has been at least one instance in Cameron County, Texas where circumstantial evidence strongly suggests that northern aplomado falcons had been shot on their artificial nest structure.

#### Collisions

Northern aplomado falcons are at risk of direct mortality from colliding with infrastructure or vehicles. An increased matrix of roads and new infrastructure in the Chihuahuan Desert could result in an increase in direct mortality to northern aplomado falcons from collisions with vehicles and infrastructure (Hager 2009, p. 211) especially while pursuing avian prey at high speeds (Keddy-Hector *et al.* 2020, accessed September 2023).

Wind turbines can result in direct mortality to northern aplomado falcon and other raptors, as well as some of its avian prey base (Erickson *et al.* 2005, pp. 1034-1036). Mortality generally occurs from direct collisions while distracted from surrounding environmental risks while hunting prey. Solar energy development has also had demonstrated impacts on avian populations, including direct mortality from reflected and concentrated solar radiation (Kagan *et al.* 2014, pp. 1-3). While this may mostly impact avian prey species, an injured bird in or near these structures could lure in a hunting falcon. This could result in a potential collision with the infrastructure while pursuing the injured prey.

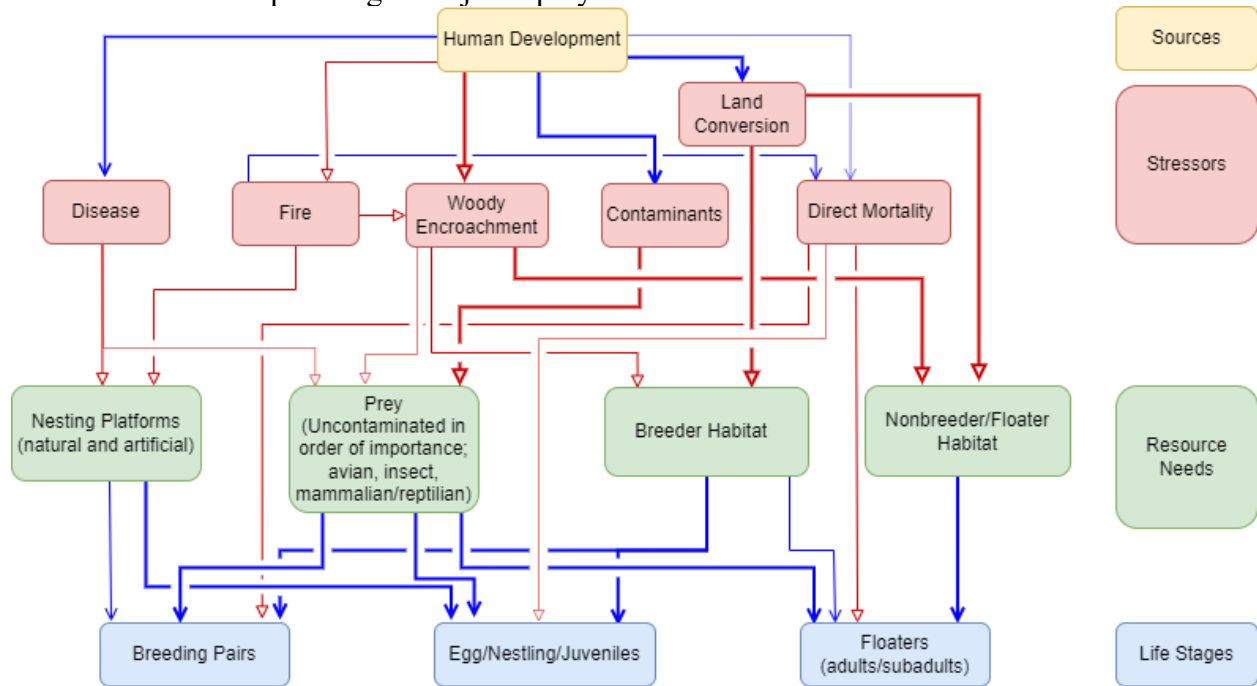


Figure 4.2. Conceptual Model illustrating the relationship between human development and resulting stressors to both habitat and resources essential to northern aplomado falcon viability. Note that arrow colors correspond to positive (blue, line arrow) or negative (red, open arrow) relationships.

#### 4.2 Stressors Considered but not Included in Viability Analysis

Other stressors were considered but not included in the Viability Analysis. One stressor is the effect of parasitism on the northern aplomado falcon. This was not included in the analysis pending the availability of more current or additional data. Hector (1982, p. 443) documented northern aplomado falcon nests in eastern Mexico infested with *Philornis* flies, which was the first known parasite of northern aplomado falcons. Hector noted that infestations may not have been documented at other nests due to the degree of infestation or simply not scrutinizing the nestlings sufficiently. To date, it is not known to what degree this type of parasitism may affect survivorship in Mexican lowland populations. The 1990 Recovery Plan shows this as a potential mortality factor, but no recent studies to date have documented nestling mortality due to botfly parasitism (USFWS 1990, p. 19).

### 4.3 Summary of Stressors

We identified two main areas of concern resulting in 10 identified stressors affecting the recovery of the northern aplomado falcon. The first area relates to the ongoing effects of environmental changes which produce stressors related to increase in fire, disease, direct mortality through the increased frequency of tropical storms or other natural events including drought, and sea level rise (Figure 4.1). The second area of stressors relates to those caused by anthropogenic factors (I.e., human development or activities). The effects of human activities produce stressors relating to disease due to changes within the ecosystem, reduced frequency of fires, and contaminants from agricultural activities; but mainly from the adverse effects of land conversions resulting in habitat loss. In some cases, human activities can result in direct mortality including shooting and destruction of nests or eggs (Figure 4.2).

## 5 SPECIES NEEDS AND CURRENT CONDITIONS

As discussed in Chapter 1, for the purpose of this assessment, viability is defined as the ability of the species to sustain populations in the wild over time. In this chapter, the demographic and habitat conditions needed for northern aplomado falcon populations to maintain resiliency and the conditions needed for species redundancy and representation are described. The current condition of populations within the species' naturally occurring range and the species' status in terms of resiliency, redundancy, and representation are also assessed.

### 5.1 Needs

The following table summarizes the individual, population and species level needs for the northern aplomado falcon and their association with resiliency, redundancy and representation.

<i>Level</i>	<i>Need</i>	<i>Function of Need</i>	<i>Association with 3 Rs</i>
<i>Individual</i>	Adequate prey	Sufficient year-round food sources that provide caloric needs for juveniles and adults	Resiliency
<i>Individual</i>	Adequate cover at roosting locations	Provides shelter from predation by great horned owls	Resiliency
<i>Individual</i>	Adequate habitat conditions to support prey	Sufficient vegetation conditions to support avian prey species	Resiliency
<i>Individual</i>	Low disease potential	Reduced potential of mortality from introduced avian diseases	Resiliency
<i>Population</i>	High abundance	A high abundance provides greater assurance of successful recruitment and the ability to withstand stochastic changes.	Resiliency
<i>Population</i>	Nesting platforms	Prevents the predation or out-competing of all life stages.	Resiliency
<i>Population</i>	High breeder survival	Improves reproductive capacity and contributes to abundance.	Resiliency

<i>Population</i>	High fecundity	Ability for breeding pairs to fledge greater than 1.5 young/year	Resiliency
<i>Species</i>	Multiple, connected, resilient populations	Improves species viability by lessening the risk of catastrophic events.	Redundancy
<i>Species</i>	Ecological and genetic diversity within the species' range	Maintains diversity and allows for adaptability to changing environmental conditions.	Representation

## 5.2 Population Resiliency

For the northern aplomado falcon to maintain viability, its populations, or some portion thereof, must be resilient; that is, they must be able to withstand stochastic events arising from spatially or temporally random factors. Stochastic events that have the potential to affect northern aplomado falcon populations may include, for example, drought, hurricanes, severe wildfires, epizootics or large point-source contaminant discharges.

Demographic factors such as fecundity; breeder survival; population abundance, distribution, and connectivity; nest site availability; and dispersal influence the viability of northern aplomado falcon populations. Influencing these factors are elements of habitat that determine whether northern aplomado falcon populations can grow to carrying capacity, thus increasing the resiliency of populations. A resilient northern aplomado falcon population needs sufficient habitat with diverse food resources to support survival and successful breeding. These relationships are shown in Figure 5.1.

To assess the current and possible future conditions of northern aplomado falcon populations, we focused on factors that influence the populations and those for which we have sufficient data. To assess the current resiliency of the three wild populations of northern aplomado falcons (Coastal Texas, Chihuahuan Desert, and Tropical Lowlands), we quantified the demographic and habitat factors described in the Population Resiliency Factors section and Table 5.1 below. These factors include fecundity, breeder survival, abundance, distribution, connectivity, nest site availability, and dispersal. Using the condition category definitions in Table 5.1, we then assigned a category of high, moderate, or low condition to each of these factors for each population. Finally, we assessed the current overall condition of each population based on its average condition category across these demographic and habitat factors, with all factors weighted equally.

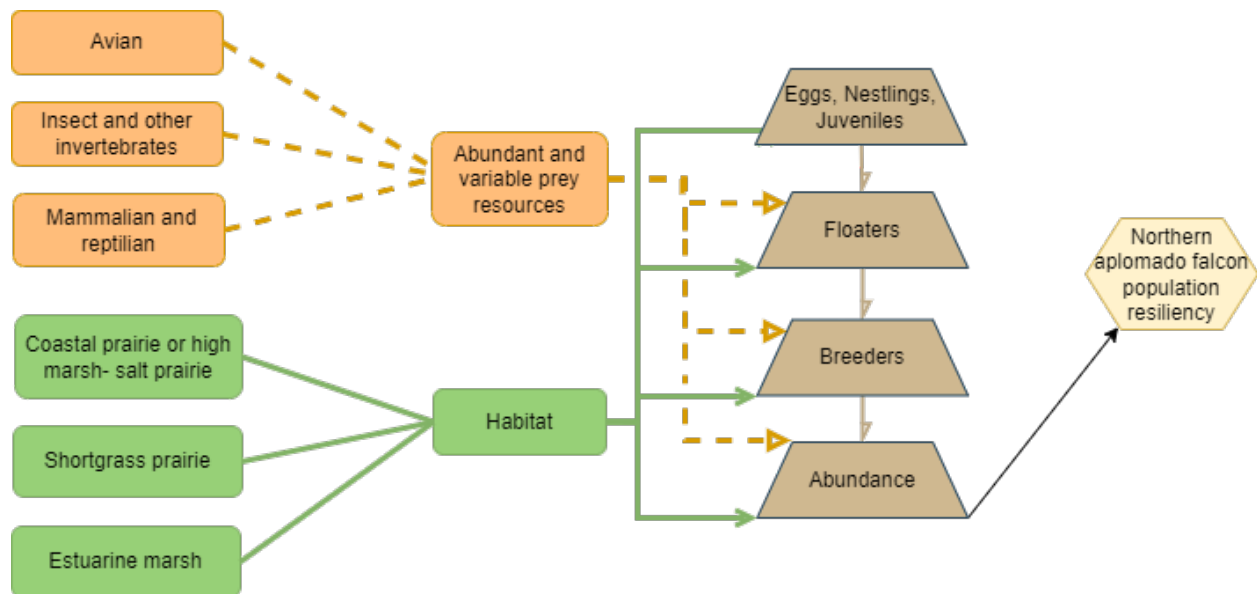


Figure 5.1. Northern aplomado falcon population resiliency. Note: the above figure includes habitats for the Coastal Texas population.

## 5.2.1 Demographic Resiliency Factors

### *Fecundity*

An integrated population model, developed by The Peregrine Fund was used to analyze population viability (Rolek et al. 2022, entire; The Peregrine Fund 2023a entire). Prior to 2012 average fecundity was below 0.58 fledglings per territorial pair and following the improvements of and increases in artificial nesting structures fecundity increased to greater than 1.74 fledglings per pair (Rolek *et al.* 2022, pp. 10-11). Additionally, independent runs of this model, conducted by the SSA team, suggests that annual fecundity will need to average >1.5 fledglings per territorial pair for a population to be viable, given the frequency and severity of the population declines that the Coastal Texas population has experienced. If conservation could increase and stabilize survival, a viable population may be possible with lower rates of fecundity. We assume this same fecundity as determined for the Coastal Texas population to be applicable across the entire subspecies.

### *Breeder Survival*

An integrated population model, developed by The Peregrine Fund developed was used to analyze population viability (Rolek *et al.* 2022, entire; The Peregrine Fund 2023a entire). Inter-annual population growth was most influenced by breeder survival (Rolek *et al.* 2022, p. 10). Breeder survival is higher than survival for other populations segments (e.g. non-breeders, first-year, etc.) and was negatively influenced by Hurricane Harvey (Rolek *et al.* 2022, p.10). Average breeder survival is 86 percent with lower- and upper-95 percent highest density intervals of 78 and 94, respectively (Rolek *et al.* 2022, p. 12). Further, independent runs of this model, conducted by the SSA team, suggests that breeder annual survival will need to average >90 percent for the population to be viable, given the frequency and severity of the population declines that the Coastal Texas population has experienced. If conservation measures could reduce frequency and severity of population declines, a viable population may be possible with lower breeder survival rates. We assume this same breeder survival as determined for the Coastal Texas population to be applicable across the entire subspecies.

### *Abundance*

Franklin's 50/500 rule estimates that a population needs at least 50 individuals to be resilient to inbreeding, and at least 500 to prevent genetic drift (as cited in USFWS 1990, p. 23). This rule may or may not be valid for northern aplomado falcons depending on their genetic variation, deleterious allele frequency, environmental stochasticity, proximity, etc., but we assume the rule applies until we have data indicating otherwise.

The 1990 Recovery Plan identified 60 territorial pairs in the U.S. in its downlisting criteria. Sixty pairs were thought sufficient to provide resilience to inbreeding depression, but the adverse effects of environmental stochasticity (including storms, disease, etc.) on the population would further exacerbate any effects from inbreeding. At the time of the Recovery Plan's development, the Chihuahuan Desert population was not known, and the Coastal Texas population had not yet been established through releases of captive bred birds. Although the Chihuahuan Desert population was discovered in 1992, demographic data for it and the Tropical Lowlands

population are limited. Following the establishment of the Coastal Texas population, beginning in 1993, it had reached a high of 44 pairs in 2005. Although this population has experienced declines, it appears to have stabilized between 23 to 28 territorial pairs. Data collected from the release and post release monitoring of the Coastal Texas population has provided a robust demographic data set. These data were largely incorporated into the analysis conducted by Rolek *et al.* (2022, entire) which informed the Integrated Population Model/Population Viability Analysis (IPM/PCVA) for all three populations (T. Anderson, pers. comm, June 12, 2024, C. McClure, pers. comm, December 9, 2024). The IPM/PCVA predicts that an initial 50-pair population's likelihood of persisting  $\geq 50$  years is roughly 70 percent (The Peregrine Fund 2023a, p. 4). Therefore, we assume that each population may be viable with at least 50 territorial pairs, depending upon how they are distributed across the landscape. In this SSA we consider a population to be in high condition if it has at least 50 pairs, moderate condition if it has 25 to 49 pairs, and low condition if there are fewer than 25 pairs in the population.

### *Distribution*

For a population to be considered in high condition for distribution, it needs to be distributed in such a way that catastrophes impact less than 20% of the population over 20 years. This is assumed to ensure adequate numbers of individuals survive so reproduction and recruitment is sufficient to replace lost individuals prior to another catastrophic event occurring. A catastrophic event could impact a substantial portion of or an entire population and may differ between coastal (e.g., hurricane, disease) and inland (e.g., drought, disease) populations. To ensure recolonization of severely impacted areas, a population needs to be large and widely distributed enough to provide sufficient recruitment and allow recolonization or immigration from marginally or unimpacted areas.

The Chihuahuan Desert population is currently centered around the nesting territories near Sueco and Tinaja Verde, in the state of Chihuahua Mexico, which are an average of 45 miles (75 km) apart (Macías-Duarte *et al.* 2009, p. 897). This population had up to 24 active nests in 2000 (Macías-Duarte *et al.* 2016, p. 213) before declining to 3 nests by 2023 (A. Macías-Duarte, pers. comm., May 5, 2024). Breeding areas within the Chihuahuan Desert population should be between 80 and 230 miles apart, based on known dispersal ability of northern aplomado falcons (Keddy-Hector 2020, accessed September 2023; Perez *et al.* 1996, p. 178; A. Macías-Duarte pers. comm. May 5, 2024), to allow for nesting success, retention, and recolonization of areas impacted from a catastrophic event. To facilitate dispersal and recolonization in impacted areas, conservation of northern aplomado falcon habitat outside of breeding areas is needed throughout the range of the Chihuahuan Desert population, including within southern New Mexico, west Texas and northern Chihuahua Mexico.

Based on Matagorda Island's territory distribution, The Peregrine Fund (Brian Mutch and Paul Juergens) estimate that each territorial pair in coastal Texas will require breeding habitat totaling roughly 2,000 acres for a territory. So, about 100,000 acres should support a 50-pair population. At this point, we estimate that the Coastal Texas population may be viable with at least 50 territorial pairs occupying suitable breeding habitat totaling at least 100,000 acres buffered from woodlands and development by  $>1$  mile of savannah-like grasslands such as salt prairie, near estuaries, and some open water. For the Coastal Texas populations, territorial pairs need to be distributed along 200 miles of undeveloped portions of the Gulf coast from Matagorda Peninsula

to northern Tamaulipas. Habitat inland and upslope of coastal areas is included to buffer against rising seas.

The Tropical Lowlands population is currently distributed across up to 700 miles of the Gulf coast and adjacent areas inland; lack of population wide surveys obscure the exact distribution and densities across the landscape. Territorial pairs in the Coastal Texas population need to be distributed along 200 miles of undeveloped portions of the Gulf coast to buffer against catastrophic events. Therefore, to maintain current population characteristics in the Tropical Lowland population, efforts to maintain the current distribution and amount of habitat should remain sufficient to allow for recolonization following a catastrophic event.

## 5.2.2 Habitat Resiliency Factors

### *Connectivity*

The disconnected nature of the current distribution of the three northern aplomado falcon populations is also a major contributor to the vulnerability of this subspecies and increases the likelihood of any of these populations being extirpated from a catastrophic event. The lack of connectivity between these populations greatly reduces the resiliency of the species to environmental impacts. This is most concerning for the Chihuahuan Desert population, which has one to three known breeding pairs in the U.S. portion of the Chihuahuan Desert, and a rapidly declining base population in the state of Chihuahua, Mexico. The possible loss of the Coastal Texas population to a catastrophic event such as a major hurricane could potentially be remedied through another captive breeding effort of falcons taken from the Tropical Lowland population in Mexico, which appeared to have been successful in the past to re-establish successful breeding pairs in that population. This augmentation strategy was apparently not successful in the Chihuahuan Desert of New Mexico. This may further indicate that the disconnected nature of the falcon's distribution is also a major contributor to the vulnerability of this subspecies to catastrophic events and increases the likelihood of any of these populations being extirpated by such an event. We assigned 80 miles as the upper limit of high connectivity, since incidents of northern aplomado falcons dispersing less than 80 miles are common (Keddy-Hector 2020, *accessed* September 2023; Perez et al. 1996, p. 178). Therefore, for a population to have high connectivity, it should be less than 80 miles from another population. For example, the Coastal Texas population would be in high condition if there were fewer than 80 miles separating it from the Tropical Lowlands population. The maximum documented dispersal distance of a juvenile northern aplomado falcon is approximately 230 miles (370 km: A. Macías-Duarte pers. comm., May 5, 2024). Therefore, for a population to be in moderate condition it must be at least 230 miles from another population. The edge of the population is determined by the edge of the furthest territory boundary that is closest to that of another population.

### *Nest Site Availability*

This metric assesses the availability of nesting sites within each population. Because northern aplomado falcons typically use stick nests in yuccas (in the Chihuahuan Desert and coastal Texas) or in tall trees with bromeliads (tropical lowlands), populations with ample natural nesting sites available will be in the high condition category. Where stick nests are not as readily available, artificial structures have been deployed to increase available nesting sites. Populations

with a combination of natural stick nests (yuccas or trees) and artificial structures will be in the moderate category. Populations with stick nests available only in shrubs or on the ground in combination with artificial structures would be considered low condition.

### *Dispersal*

Aplomado falcon dispersal seems to be female-biased (females disperse more frequently and further away than males) in the northern aplomado falcon as noted in Hunt et al. (2013, p. 344) and Perez et al. (1996, p. 177). Functional hypotheses for this pattern include avoiding inbreeding resource competition (Trochet *et al.* 2016, p 299). A long-term, intense monitoring of the restored population in coastal Texas provides no evidence of females breeding in their natal territory (P. Juergens, pers. comm., March 27, 2023), whereas there is an instance of a female breeding in her natal territory in the declining Chihuahuan Desert population (Macías-Duarte *et al.* 2020, p. 21).

Populations where females do not breed in their natal territories are considered in high condition and those where females do breed in their natal territories are considered in low condition. We do not define moderate condition for dispersal.

Table 5.1. Current condition categories

<b>Condition Category</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>
<b>High</b>	>2.0	0.92+	≥50 pairs (Ne) in populations	Distributed in such a way that catastrophes impact less than 20% of the population over 20 years	Populations are less than 80 miles apart	Stick nests available - in yuccas or tall trees with bromeliads (in tropical lowlands)	Ample resources are available, and females establish breeding territories outside of their natal territory
<b>Moderate</b>	1.2 - 2.0	0.9 - 0.92	<50 ≥25 pairs (Ne) in populations	Distributed in such a way that catastrophes impact no more than 30% of the population and occur less than once every 20 years	Populations are between 80 miles and 230 miles apart	Combo of natural stick nests in yuccas and artificial structures	This factor is not defined for moderate condition.
<b>Low</b>	<1.2	< 0.9	<25 pairs (Ne) in populations	Distributed in such a way that catastrophes impact 30% or more of the population	Populations are greater than 230 miles apart	Artificial structures available and natural stick nests in shrubs or on ground	Resources are limited and females return to their natal territory to breed

## 5.3 Current Conditions

### 5.3.1 Current Population Resiliency

#### *Coastal Texas*

The overall current condition of the Coastal Texas population is low. Fecundity has averaged 1.74 since 2011 and average annual breeder survival since 1993 is 86 percent (Rolek *et al.* 2022, pp. 10 and 12), placing the Coastal Texas population in moderate condition for fecundity and low condition for breeder survival. As of 2022, there were 23 territorial pairs (The Peregrine Fund 2022a, p. 3), placing the population in low condition for abundance. Distribution is such that catastrophic events could impact more than 20 percent of the population during a 20-year span - and did so as recently as 2017 when Hurricane Harvey made landfall on the middle Texas coast - placing distribution in low condition. Protecting habitat along a greater stretch of coastline to facilitate increased distribution along the coast would allow the population to be resilient to hurricanes. Woody encroachment and development upslope from currently occupied breeding habitat will make it difficult for the population to shift upslope with rising seas unless conservation measures are taken to protect potential habitat upslope from development, clear it of woodlands, and maintain it with frequent fire or occasional coastal flooding. Stick nests and yuccas are widely available on the lower Texas coast but are quite limited in the middle Texas coast. Artificial nest structures are needed and have been constructed to supplement natural nesting structures along the Texas coast, placing nest site availability in moderate condition. Juveniles are dispersing into territories between 6 and 80 miles away from natal habitat (Perez *et al.* 1996, p. 180); placing dispersal in high condition.

#### *Chihuahuan Desert*

The overall current condition of the Chihuahuan Desert population is low. As of 2021, the only confirmed breeding pair in New Mexico is in Luna County south of Deming New Mexico. There had been sightings near Otero Mesa and three other nesting attempts observed on the Armendaris Ranch in Sierra County during the 12-year period of captive bred releases. None of those three territories were considered to still be active as of 2021 (La Tierra 2022, pp. 2-3). There have also been up to three nesting territories on private lands in west Texas, last confirmed in 2020 (A. Montoya, pers. comm., February 6, 2024). The population in the State of Chihuahua, Mexico has recently lost much of its habitat to cultivation and has declined to approximately 10 territorial pairs distributed near Sueco and Tinaja Verde (A. Macías-Duarte, pers. comm., May 5, 2024). Even optimistically, there currently appears to be fewer than 15 breeding pairs in the Chihuahuan Desert population in Mexico (A. Macías-Duarte, pers. comm., May 5, 2024). Therefore, together the Chihuahuan Desert population is comprised of fewer than 20 breeding pairs, placing it in low condition for abundance. Given the population declines, fecundity and breeder survival are considered in low condition for the Chihuahuan Desert population.

The low number of known breeding pairs and their distribution (low condition) makes the Chihuahuan Desert population highly susceptible to local extirpation from any number of possible stressors, including direct mortality from predation, disease, drought, or starvation from a reduced prey base or territorial abandonment. This has resulted in an effective population size that is apparently well below the minimum number of breeding pairs in the Chihuahuan Desert to

maintain even a low level of abundance (Table 5.1). Probable causes for this low number include loss of functional habitat from agricultural and energy development, grazing impacts to desert grassland vegetation that are exacerbated by changes in fire cycles and changing climatic conditions (e.g., higher temperatures, drought), a reduction in potential avian prey and a lack of nesting structures resulting from development, grazing impacts and altered fire cycles. Additionally, populations of its main nest builder, the Chihuahuan raven, are in decline throughout the species' range (Fink *et al.* 2023, accessed 2023). A combination of available natural stick nests and artificial nesting structures places nest site availability in moderate condition. While contamination from organochlorine pesticides had been an original concern in listing the species, more recent research has not shown this to be a major concern now (Mora *et al.* 2011, p. 3436). There is an instance of a female breeding in her natal territory in the declining Chihuahuan Desert population (Macías-Duarte *et al.* 2020, p. 21); placing dispersal in low condition.

### *Tropical Lowlands*

Few data are available for the Tropical Lowlands population. In central Veracruz, surveys during the 2022 breeding season indicated that the number of fledglings per nest had declined to 0.55 fledglings per nest from those reported in 2006-2007 (1.53 fledglings per nest) (The Peregrine Fund 2023b, p. 4). Although these data are only from central Veracruz, they represent our best information for the Tropical Lowland population and suggest low current condition for fecundity. We lack specific data on breeder survival for this population, however, because breeder survival is often correlated to population growth in species with slow life histories such as falcons, including the northern aplomado falcon (Rolek *et al.* 2022, p. 14), and eBird population trend information suggests declining trends in abundance (Figure 3.5) we assume breeder survival is less than 0.9. We estimate the total Tropical Lowlands population currently consists of at least 280 pairs spread throughout Mexico and Central America within the subspecies' range; 84 pairs were detected in central Veracruz in 2022 (The Peregrine Fund 2023b, p. 3). It is considered large and is widely distributed enough to be fairly resilient to hurricanes and occurs far enough inland (The Peregrine Fund 2022b, pp. 7-8) to be considered resilient to rising seas. The Tropical Lowlands population is distributed along approximately 700 miles of the Gulf Coast. Major hurricanes along the north and west Gulf Coast in the U.S. occur, on average, approximately once every 30 years and direct impact zones are approximately 50 miles wide (Blake *et al.* 2011, pp. 3 and 26). In this SSA we assume these average data are applicable to the Gulf Coast in Mexico. Given the subspecies distribution along 700 miles of coastal and inland areas and the populations estimated size, it is reasonable to assume that less than 30 percent of the population would be impacted by catastrophic events over 20 years. Therefore, its resiliency to hurricanes and rising seas is considered moderate. Live tree fences and pastures are maintained across the range of this population, suggesting nest site availability and dispersal are in high condition.

### 5.3.2 Current Redundancy

To provide for species redundancy, the northern aplomado falcon needs to have multiple resilient populations distributed throughout its range. The greater the number of populations, and the wider the distribution of those populations, the more redundancy the species will exhibit.

Redundancy reduces the risk that a large portion of the falcon's range will be negatively affected by a catastrophic natural or anthropogenic event, such as a hurricane, at a given time.

Northern aplomado falcons comprise three populations that occur throughout the species' historical range. However, two populations, Coastal Texas and Chihuahuan Desert, are in low condition. The Tropical Lowlands population is currently in moderate condition, which provides some level of redundancy for the species; however, two populations in low condition suggest current redundancy is not secure for the subspecies. There is no known connectivity between the Coastal Texas, Chihuahuan Desert, and Tropical Lowland populations. The populations are approximately 600 km (373 mi Coastal Texas and Tropical Lowland populations, (C. Perez, pers. comm., June 3, 2024) to 1100 km (684 mi Chihuahuan Desert and Tropical Lowlands populations: Macías-Duarte *et al.* 2004, p. 1082) apart. Although the three populations are geographically separate, which limits the risk of any single catastrophic event impacting the entire subspecies, retaining population redundancy requires conservation actions that increase the resiliency of the Chihuahuan Desert and Coastal Texas populations. Such actions will help ensure persistence of the three current populations distributed across multiple habitat types throughout the subspecies range.

### 5.3.3 Current Representation

Representation in the form of genetic or ecological diversity is important to maintain the capacity of northern aplomado falcons to adapt to future environmental changes. While breeding populations within the tropics, Chihuahuan Desert, and coastal Texas are hundreds of miles apart, the northern aplomado falcon is wide-ranging, and individuals have been documented to have dispersed up to 230 miles (370 km: A. Macías-Duarte, pers. comm., May 5, 2024). Juveniles may disperse to different breeding populations away from their natal areas. Given this, genetic mixing between the tropics, Chihuahuan Desert, and Coastal Texas populations could occur if they occupied habitat within 230 miles of one another. However, it is unlikely that individuals from the Coastal Texas, Chihuahuan Desert, and Tropical lowland populations interact with each other on a regular basis, so genetic divergence between the three populations may be occurring over time. The use by northern aplomado falcons of multiple grassland types indicates a level of ecological diversity that may allow for adaptation to changes in the environment over time. Continued distribution among the different habitat types could be important in maintaining ecological representation, particularly because these habitat types are interspersed throughout the current range.

There is one inland population (Chihuahuan Desert) and two coastal populations (Coastal Texas and Tropical Lowlands) of northern aplomado falcons. As described above in section 2.3.3 Habitat, these populations occupy grasslands, shrub-steppe ecosystems, and open habitats within tropical forests (rainforest and dry forest). Because the Coastal Texas population was established through captive breeding and releases, it is genetically redundant with the source population in the Tropical Lowlands. Although releases of captive-reared falcons also occurred in northern portions of the Chihuahuan Desert in the U.S., the Chihuahuan Desert population is overall thought to consist primarily of falcons that are native to the Chihuahuan Desert population, as no releases occurred within Mexico where the majority of breeding pairs persist. It is possible, however, that breeding between naturally occurring and captive-reared falcons in the Chihuahuan Desert has occurred; movement across the international border has been

documented and not all offspring of both naturally occurring and captive-reared falcons have been banded. Although sample sizes were small, research suggests that northern aplomado falcons that are native to the Chihuahuan Desert are genetically distinct from those in the tropical lowlands of Mexico (Johnson and Stock 2017, p. 9) and by default those in coastal Texas. The breadth of both genetic and ecological diversity of the northern aplomado falcon are at risk. The Chihuahuan Desert population consists of one to three pairs in the U.S. portion of the Chihuahuan Desert (La Tierra 2022, p. 2; A. Montoya, pers. comm., February 6, 2024) and fewer than 15 pairs in the State of Chihuahua, Mexico (A. Macías-Duarte, pers. comm., May 5, 2024).

Table 5.4. Northern aplomado falcon current conditions

<b>Population</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>	<b>Current Condition</b>
Coastal Texas	Moderate	Low	Low	Low	Low	Moderate	High	Low
Chihuahuan Desert	Low	Low	Low	Low	Low	Moderate	Low	Low
Tropical Lowlands	Low	Low	High	Moderate	Low	High	High	Moderate

## 6 FUTURE SCENARIOS

Previous chapters have included information on the stressors that are driving the historical and current conditions of the northern aplomado falcon. This includes consideration of demographic and habitat factors that affect the species' viability, and examination of the current conditions of breeding populations in coastal Texas, the Chihuahuan Desert Grasslands in the U.S. and Mexico, and the Tropical Lowlands in Mexico. Here, the future viability of the northern aplomado falcon is assessed by applying future forecasts to the concepts of resiliency, redundancy, and representation. These risk assessments are necessary to inform agency recovery actions and decisions, as they provide an understanding of plausible future conditions of the species and its habitat.

### 6.1 Scenario Assessment

Future stressors and levels of conservation efforts are uncertain. For this reason, northern aplomado falcon resiliency, redundancy, and representation were forecasted under three plausible future scenarios. These future scenarios forecast the viability of northern aplomado falcons based on different potential levels of habitat loss from human development and sea level rise, increasing risk of major hurricanes and long-term drought, and conservation actions on corresponding timelines over the next 45 to 60 years. Future land use projections for the SSA report were derived from 2020 USGS LCMMap data compared with EPA ICLUS (Integrated Climate and Land Use Scenarios) V.2, 2080 data. Both datasets were reclassified (slightly simplified) and projected to match to identify the differences between the 2 datasets. The land use changes from 2020 to 2080 were then calculated for the report (Tables 4.2 and 4.4 above: see USFWS 2024b, for additional details).

The impacts of these stressors and conservation efforts on demographic and habitat factors were used to assess future conditions. Each scenario was analyzed separately for each of the three populations: Coastal Texas, Chihuahuan Desert and Tropical Lowlands in eastern Mexico. Scenario 1 represents a scenario where stressor trends continue at current rates and conservation efforts are estimated to be such that they adequately abate stressors by 2080 (60 years from the start of this report). Scenario 2 represents a scenario with moderate increases in future stressors and implementation of conservation efforts by 2074 [6 years (10%) sooner than current rates], and Scenario 3 represents a scenario with high levels of future stressors and implementation of conservation efforts by 2068 [12 years (20%) sooner than current rates] (Table 6.1). These scenarios do not include all possible combinations of future impacts and conservation efforts, and there is uncertainty associated with them, but they represent estimated timelines thought necessary for implementation of conservation measures under varying levels of increasing stressors. We assume that all the conservation measures are successfully implemented within the associated timeframes.

Table 6.1. Summary of future scenarios.

<b>Scenario</b>	<b>Stressors</b>	<b>Conservation actions completed by:</b>
1	Continuation of current trends	2080
2	Moderate stressor increase	2074
3	Greater stressor increase	2068

## 6.2 Potential Future Risk Factors and Conservation Actions

Possible future conservation actions in Mexico, southern New Mexico, and Texas were assessed. Potential conservation actions could include the restoration, maintenance and protection of northern aplomado falcon habitat including but not limited to the development of programs to implement conservation measures on privately owned lands, minimizing the impacts of natural resource and renewable energy development on avian species, and developing and implementing programs to conserve northern aplomado falcon genetic diversity.

### 6.2.1 Coastal Texas

Principal threats to the Coastal Texas population come from woody encroachment, development, and rising seas. These threats all destroy or alter habitat conditions needed for northern aplomado persistence. The increasing frequency of major hurricanes also threatens to reduce survival of northern aplomado falcons and degrade or result in loss of habitat. We estimated land use change from human development (2020 to 2080) through comparisons of USGS Land Change Monitoring, Assessment, and Projection (LCMap) 2020 and future (2080) projections modeled by EPA ICLUS (Integrated Climate and Land Use Scenarios) V.2 (Table 4.3: USFWS 2024b, p. 1). The resulting change of 0.3 percent annually was applied to Scenario 1, and to estimate annual change under increasing stressor scenarios the rate was doubled (0.6%) or tripled (0.9%) in Scenarios 2 and 3, respectively. Coastal habitat loss from rising seas and land subsistence is occurring and is predicted to continue into the future (Smith *et al.* 2014, p. 2). Rising sea levels not only impact salt marshes but are expected to inundate low lying upland habitats, increasing estuarine habitats (Smith *et al.* 2014, p. 3). Smith *et al.* (2014, pp. 78-82) projected significant irregularly flooded estuarine marsh loss to rising seas under various sea level-rise scenarios by 2075 and 2100. Scenarios with ~.69m and 1m sea level rise suggest that 17 to 37 percent and 37 to 68 percent of irregularly flooded marsh may be lost by 2075 and 2100, respectively; a scenario with 2m sea level rise suggests nearly all of this marsh type will be lost (Smith *et al.* 2014, pp. 76-81). The conversion of upland habitats or irregularly flooded marsh to estuarine habitat will reduce northern aplomado falcon habitat used for breeding and feeding. Major hurricanes also contribute to land loss from rising seas through erosion of coastal habitat (CPRAL 2017, p. ES-2), and as the incidence of major hurricanes increases, increased coastal erosion is also likely to occur. The northern aplomado falcon PVA modeled Category 4 and 5 hurricanes along the Gulf Coast occurring approximately once every 30 years (Blake *et al.* 2011, p. 26), this rate of major hurricanes making landfall was applied to Scenario 1. Modeling by the National Hurricane Center for Atmospheric Research suggests a 2- to 4.5-fold increase in the frequency of major hurricanes going forward (Bruyere *et al.* 2017, p. 69), and the PVA modeled impacts from catastrophic events at once every 30 years (current (0.033) annual risk), once every 15 years (0.067 annual risk) and once every 10 years (0.10 annual risk), which is within the predicted increases in severe hurricanes for coastal populations. Therefore, for Scenarios 2 and 3, major hurricane risk was increased to 15- and 10-year return intervals, respectively. The expansion of woody vegetation into coastal grasslands and marshes creates suboptimal hunting conditions, increases predation risk, and can result in avoidance of areas that previously provided habitat. This degradation and loss of habitat is a major concern for the Coastal Texas population; however, sufficient data were not available to include it in assessments of future condition. We

considered changes in coastal habitat availability when determining the distribution of habitat needed to be conserved in coastal and upslope areas (i.e., areas upslope and inland from the coastline).

We estimate that maintaining a viable northern aplomado falcon population resilient to these stressors will require that we increase the annual survival rate of adults to  $\geq 90$  percent and maintain fecundity at  $\geq 1.5$  fledglings/territorial pair. The northern aplomado falcon PVA model suggests a viable Coastal Texas population must be at least 50 pairs (The Peregrine Fund 2023a, p. 4). According to Peregrine Fund field staff, each pair's territory is likely to be roughly 2,000 acres. So, a viable Coastal Texas population will require at least 100,000 acres. Sea level rise projections, discussed above, suggest that much of coastal Texas' irregularly flooded estuarine marsh will be lost to rising seas by 2080. Since irregularly flooded estuarine marsh is a main component of northern aplomado falcon habitat in coastal Texas, we estimate conservation measures will need to be implemented by 2080 under Scenario 1, by 2074 under Scenario 2, and by 2068 under Scenario 3 to offset increasing rates of habitat loss assumed under these Scenarios. A viable Coastal Texas population will likely require habitat protected from development spread out along a stretch of coastline such that hurricanes making landfall in coastal Texas will impact a small enough portion of the population that it will have time to recover before a subsequent hurricane makes landfall. A population resilient to rising seas will also require buffer habitat conserved upslope from breeding habitat so that breeding habitat will be able to transition upslope as sea levels rise. This buffer will also provide habitat for non-breeding "floaters" which can occupy breeding territories as breeders die off. For the Coastal Texas population to remain viable, future conservation actions will need to be commensurate with development and trends in climatic conditions. Habitat will need to be conserved along a longer stretch of coastline with increased hurricane frequency, and habitat protection will need to be accelerated with accelerating development and sea level rise rates. Given current development and projected sea level rise, and hurricane frequency trends in coastal Texas, we believe that protecting  $>100,000$  acres of breeding habitat will support a population resilient to development, hurricanes, and rising seas if it is spread out over a stretch of coastline  $>200$  miles and is buffered with additional open habitat  $>1$  mile upslope from breeder habitat in salty prairie, deep sand grasslands, and coastal prairies by 2080. If development rates and hurricane frequency increase at the rates indicated above, we believe that habitat will need to be protected along a stretch of coastline  $>200$  miles by 2074. If development rates and hurricane frequency increase at the rates indicated above, we believe that habitat will need to be protected along a stretch of coastline  $>200$  miles by 2068 (Table 6.2). The further inland the protected habitat extends, the less distance it would need to be spread out along the coast. This conservation area is likely to be located between the Matagorda Peninsula to northern Tamaulipas.

### 6.2.2 Chihuahuan Desert

Principal threats to the Chihuahuan Desert population come from development (primarily agriculture in Mexico and urban/commercial development in the U.S.) and environmental changes (primarily through drought), which result in the degradation and loss of habitat. In the U.S., two percent of Chihuahuan Desert grassland (approximately 758,313 ac) has been lost to some form of change over 34 years between 1986 and 2020 (Table 4.1: USFWS 2024b, pp. 4-5). Most of this was lost to agricultural conversion (48%), but a significant portion has also been lost to urban development (26%) and other vegetation loss resulting in disturbed or barren land

(27%). Future modeling of potential loss over the next 60 years, under increasing emissions scenario RCP 8.5, indicates that an additional 5 percent could no longer function as northern aplomado falcon habitat by impacts from these same factors (Table 4.2: USFWS 2024b, pp. 6-7). One major difference in this future model is that most of this habitat loss would be from rural development (79%) as well as urban and suburban development (15%) and commercial development, including roads and associated infrastructure (6%). Additionally, any future land conversion in trans-Pecos Texas from urban or suburban development will be minimal, as this part of west Texas will likely see a reduced human population through 2050 (Texas Demographics Center 2022, entire). Loss to agricultural development is occurring mostly in Chihuahua, Mexico (USFWS 2024c, entire). The loss to agriculture is negligible in the U.S., at less than 0.1 percent of the total loss in the U.S. Effective conservation measures need to be implemented to abate this projected loss.

Projections of future habitat loss from human development are not available for the Chihuahuan Desert in Mexico. To better understand the impacts of agricultural development in areas occupied by northern aplomado falcons, we evaluated Landsat imagery in GIS from 1986 and 2021. Within this focused area in the state of Chihuahua, Mexico, approximately 557,205 acres (2,255 km<sup>2</sup>) of Chihuahuan Desert grassland was lost to agricultural conversion from 1986 to 2021, primarily in the form of irrigated cropland (USFWS 2024c, pp. 9-10). This represents an approximate 442 percent increase in the conversion of desert grassland to agricultural use. Substantial conversion occurred within the breeding center of Sueco within the Valle Centrales. The two breeding centers, Sueco and Tinaja Verde, supported at least 24 active nesting territories between 1996-2002 (Macías-Duarte *et al.* 2016, p. 213). As of 2023, fewer than 3 of these historical nest sites remain active (A. Macías-Duarte, pers. comm., May 5, 2024). Although we do not know how much desert grassland was converted annually from 1986 to 2021, assuming a constant rate over time, 15,920 acres (approximately 64 km<sup>2</sup>) was lost annually to agricultural conversion. Given that much of the desert grassland considered optimal for agricultural conversion has already been converted, it is unlikely that future rates of desert grassland loss to agricultural development in the focus area will remain as high. Further, current drought trends have impacted the viability of agriculture in some areas, resulting in the abandonment of fields. In some instances, northern aplomado falcons have been observed using abandoned agricultural fields (A. Macías-Duarte, pers. comm., May 5, 2024), suggesting that field abandonment under increasing climate stress may offset, to some degree, habitat loss to future agricultural development. Because of the complexities (losses and potential gains) associated with understanding future habitat loss in the focus area, and the lack of modeling across the Chihuahuan Desert in Mexico, for the purposes of this SSA we apply the levels of habitat loss in the U.S. to all of the Chihuahuan Desert in future scenarios. Therefore, for the Chihuahuan Desert population under Scenario 1, habitat loss from human development is expected to result in the loss of 2 percent of desert grassland over the next 60 years, and we assume that under future Scenarios 2 and 3 the current rate will double or triple, respectively. Under Scenario 2, then, we assume a 4 percent loss in desert grassland and under Scenario 3 a 6 percent loss in desert grassland over the next 60 years (Table 6.3).

Within the Chihuahuan Desert, expected environmental changes include warming temperatures, including intensifying heatwaves with higher frequency and duration, and although precipitation will decline, the timing of it will alter, as more precipitation is anticipated to be associated with

heavier and more intense events. Such changes will increase aridity and intensify droughts (Hicke *et al.* 2022, pp. 1937-1938). In the Chihuahuan Desert, such trends have influenced changes in vegetation community structure by favoring shrub community expansion over grasslands (Petrie *et al.* 2015, pp. 1232-1233). The reduction in *Bouteloua* grasses and increase in shrub dominance can have a significant impact on overall vegetation community structure and biodiversity (Baez and Collins 2008, pp. 6-7), which could negatively impact northern aplomado falcon prey species abundance. In the southwestern U.S. and northern Mexico, duration of severe droughts has averaged around 19-20 years (Williams *et al.* 2020, entire). This region is currently experiencing a megadrought that has surpassed the average duration and may exceed the last severe megadrought which occurred in the late 1500s (Williams *et al.* 2020, p. 314). Recent analyses have extended the average duration of such severe droughts to 23 years, with some models predicting durations of over 30 years in the future (Williams *et al.* 2022, p. 234). Therefore, for Scenarios 2 and 3, drought duration and frequency were increased from 20-year droughts every 125 years, to 25-year droughts every 100 years and 30-year droughts every 75 years, respectively.

We estimate that maintaining a viable northern aplomado falcon population resilient to these stressors will require that we increase the annual survival rate of adults to  $\geq 90$  percent and increase fecundity to  $\geq 1.5$  fledglings per territorial pair. The northern aplomado falcon PVA suggests, a viable Chihuahuan Desert population must be at least 50 pairs (The Peregrine Fund 2023a, p.4). Home range size for breeding adult northern aplomado falcons has ranged from 3.3 to 21.4 km<sup>2</sup> (Montoya *et al.* 1997, p. 138) to, more recently, 200 km<sup>2</sup> using satellite telemetry from a breeding male (Macías-Duarte *et al.* 2021, p. 271). A substantial amount of northern aplomado breeding habitat was converted to agricultural land between 1997 and 2021, which likely contributed to the increased home range size (n=1) reported in 2021. Therefore, because research suggests that home range size has increased but small sample size makes the determination of extent uncertain, for the purposes of this SSA we considered the home range for a breeding pair as 72 km<sup>2</sup>. We extrapolated this to estimate the number of acres of habitat that must be conserved to support at least 50 breeding pairs; approximately 889,580 acres. Therefore, conserving a viable Chihuahuan Desert aplomado falcon population will require the restoration, maintenance, and protection of habitat totaling 889,580 acres. Because there are currently fewer than 15 breeding pairs in the Chihuahuan Desert population, in Mexico, establishment and growth of a genetically appropriate captive population is needed to support releases and grow the population. We project that all conservation actions will need to be implemented by 2080 under Scenario 1, by 2074 under Scenario 2, and by 2068 under Scenario 3 to offset increasing rates of habitat loss and drought assumed under these scenarios (Table 6.3).

### 6.2.3 Tropical Lowlands

Principal threats to the Tropical Lowlands population come from environmental changes, as there are no anticipated significant changes to current levels of human development. Most lowland forests in the state of Veracruz have been cleared to pastureland (44%) and agriculture (27%) (Landeros *et al.* 2011, p 479); therefore, not much unaltered tropical forest remains. The establishment and conservation of live tree fences in pastures, however, is necessary to maintain adequate nesting structures (SEMARNAT 2018, p 28). In the event adequate nesting structures are not available, installation of artificial nesting structures may be beneficial. Additionally, open

pastureland needs to be managed to avoid unsuitable secondary vegetation, and measures to control illegal take of falcon nestlings by falconers are needed (SEMARNAT 2018, p 28).

Analyses on impacts from rising seas and major hurricanes were not available for coastal areas within Mexico; therefore, we assumed similar impacts from rising seas and hurricanes as projected for coastal Texas for all scenarios. To estimate the number of acres of habitat needed to be conserved in the Tropical Lowlands, we calculated the number of acres needed to support the current estimated population size. Population-level surveys have not been conducted in the Tropical Lowlands. Therefore, we estimated the minimum number of northern aplomado falcon pairs currently in the Tropical Lowlands (280) by applying the density of falcons in the Coastal Texas population prior to hurricane Harvey to the miles of coastal areas occupied in the Tropical Lowlands (700 miles). This likely underestimated the number of northern aplomado falcon pairs in the Tropical Lowlands, because we only estimated the numbers of falcons on the Bay of Campeche from about Tampico to around Campeche. There are an unknown number of additional northern aplomado falcons in inland areas, north of Tampico, along the Gulf Coast, and along the Pacific coast. Because this population already supports greater than 50 pairs, it is important to conserve sufficient habitat to maintain at least the current estimated population size. We assume the average territory size in the tropical lowlands as 1,500 acres ( $>5 \text{ km}^2$ ) as  $>5 \text{ km}^2$  was the minimum habitat patch size applied by Keddy-Hector et al. (2014 entire) while mapping potential habitat in Mexico.

We estimate that maintaining the 280 northern aplomado falcon pairs comprising the Tropical Lowlands population will require that we protect habitat totaling  $>420,000$  acres, increase the annual survival rate of adults to  $\geq 90$  percent, and increase fecundity to  $\geq 1.5$  fledglings/territorial pair. We project that all conservation actions will need to be implemented by 2080 under Scenario 1, by 2074 under Scenario 2, and by 2068 under Scenario 3 to offset the impacts from increasing stressors under these scenarios.

### **6.3 Future Scenarios**

The information provided above guided development of future scenarios for each population: Coastal Texas (Table 6.2), Chihuahuan Desert (Table 6.3), and Tropical Lowlands (Table 6.4).

Table 6.2. Future scenarios for the Coastal Texas population of northern aplomado falcons. Note: Sea level rise is abbreviated as SLR.

<b>Scenario</b>	<b>Human Development</b>	<b>Environmental Changes</b>	<b>Conservation</b>
1	<u>Habitat Loss to 2080:</u> 0.3% annually	<u>Major Hurricanes:</u> 30-year return interval (50% loss breeders); <u>SLR:</u> constant to 2080, diminishes by 2100	Conserve >100,000 acres of breeding habitat with a nearly treeless 1-mi. buffer upslope extending >200 miles along the Texas coast, adult survival >90%, and fecundity $\geq 1.5$ fledglings per territorial pair by 2080
2	<u>Habitat Loss to 2080:</u> 0.6% annually	<u>Major Hurricanes:</u> 15-year return interval; <u>SLR:</u> constant to 2074, diminishes by 2092	Conserve >100,000 acres of breeding habitat with a nearly treeless 1-mi. buffer upslope extending >200 miles along the Texas coast, adult survival >90%, and fecundity $\geq 1.5$ fledglings per territorial pair by 2074
3	<u>Habitat Loss to 2080:</u> 0.9% annually	<u>Major Hurricanes:</u> 10-year return interval; <u>SLR:</u> constant to 2068, diminishes by 2084	Conserve >100,000 acres of breeding habitat with a nearly treeless 1-mi. buffer upslope extending >200 miles along the Texas coast, adult survival >90%, and fecundity $\geq 1.5$ fledglings per territorial pair by 2068

Table 6.3. Future scenarios for the Chihuahuan Desert population of northern aplomado falcons.

Scenario	Human Development	Environmental Changes	Conservation
1	<u>Habitat Loss to 2080:</u> 2% of current	<u>Long duration drought:</u> 20-year droughts every 125 years (Interim shorter duration droughts still occur)	Conserve > 889,580 acres, adult survival >90%, fecundity $\geq$ 1.5 fledglings per territorial pair, and genetically appropriate breeding and release program by 2080
2	<u>Habitat Loss to 2080:</u> 4% of current	<u>Long duration drought:</u> 25-year droughts every 100 years (Interim shorter duration droughts still occur)	Conserve >3.6 million 889,580 acres, adult survival >90%, fecundity $\geq$ 1.5 fledglings per territorial pair, and genetically appropriate breeding and release program by 2074
3	<u>Habitat Loss to 2080:</u> 6% of current	<u>Long duration drought:</u> 30-year droughts every 75 years (Interim shorter duration droughts still occur)	Conserve > 889,580 acres, adult survival >90%, fecundity $\geq$ 1.5 fledglings per territorial pair, and genetically appropriate breeding and release program by 2068

Table 6.4. Future scenarios for the Tropical Lowlands population of northern aplomado falcons.

Scenario	Human Development	Environmental Changes	Conservation
1	No Change	<u>Major Hurricanes:</u> 30-year return interval (25% loss breeders); <u>SLR:</u> constant to 2080, diminishes by 2100	Conserve >420,000 acres, adult survival >90%, and fecundity $\geq$ 1.5 fledglings per territorial pair by 2080
2	No Change	<u>Major Hurricanes:</u> 15-year return interval; <u>SLR:</u> constant to 2074, diminishes by 2092	Conserve >420,000 acres, adult survival >90%, and fecundity $\geq$ 1.5 fledglings per territorial pair by 2074
3	No Change	<u>Major Hurricanes:</u> 10-year return interval; <u>SLR:</u> constant to 2068, diminishes by 2084	Conserve >420,000 acres, adult survival >90%, and fecundity $\geq$ 1.5 fledglings per territorial pair by 2068

## 6.4 Future Resiliency:

### 6.4.1 Coastal Texas

Under all future Scenarios, the Coastal Texas population is expected to be in an overall moderate condition. Restoring, maintaining and conserving greater than 100,000 acres of northern aplomado falcon habitat with a nearly treeless 1-mi. buffer upslope from the breeding habitat in salty prairie, deep sand grasslands, and coastal prairies is sufficient to support a population of over 50 pairs. Restoring and maintaining open grassland habitats will provide ample food resources and minimize predation risk, helping to ensure that fecundity and adult survival are sufficient to maintain a stable or growing population. Habitat will be conserved along at least 200 miles of the Texas coast from Matagorda Peninsula to northern Tamaulipas, Mexico and include sufficient inland and upslope habitat to buffer against direct mortality and habitat loss from major hurricanes and rising sea levels. We project that fecundity will be in moderate condition (1.2 and 2 fledglings per territorial pair), breeder survival in moderate condition (0.9 to .092 survival), and abundance in high condition (greater than 50 pairs). The Coastal Texas population is projected to be distributed such that hurricanes or other catastrophic events will impact no more than 20 percent of the population every 20 years (high condition). Connectivity will be in low condition, as the Coastal Texas population will remain >230 miles from other populations. Availability of nesting structures will be in moderate condition because both yuccas and artificial nesting structures are widely available. Dispersal will be in high condition because females continue to establish breeding territories outside of their natal territory.

Table 6.5. Future conditions for the Coastal Texas population under all future scenarios.

<b>Scenario</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>	<b>Overall Condition</b>
1	Moderate	Moderate	High	High	Low	Moderate	High	Moderate
2	Moderate	Moderate	High	High	Low	Moderate	High	Moderate
3	Moderate	Moderate	High	High	Low	Moderate	High	Moderate

## 6.4.2 Chihuahuan Desert

Under all future Scenarios, the Chihuahuan Desert population is expected to be in an overall moderate condition. Restoring, maintaining and conserving greater than 889,580 acres of northern aplomado falcon habitat is sufficient to support a population of at least 50 pairs. Restoring and maintaining open desert grassland habitats will provide ample food resources and minimize predation risk helping to ensure that fecundity and adult survival are sufficient to maintain a stable or growing population. Habitat will be conserved across U.S. and Mexican portions of the Chihuahuan Desert. Distance between patches of conserved habitat should be less than the maximum documented dispersal distance for juvenile northern aplomado falcons (230 mi/320 km) to facilitate successful dispersal. We project that fecundity will be in moderate condition (between 1.2 and 2 fledglings per territorial pair), breeder survival in moderate condition (0.9 to 0.92 survival), and abundance in moderate condition (>25 and <50 pairs). Habitat loss from agriculture and renewable energy development, and drought duration and frequency are projected to increase under all three Scenarios. There are currently <15 breeding pairs in the Chihuahuan Desert. A genetically appropriate breeding program needs to be established which will take time to grow to the size needed to facilitate sufficient releases into the wild. Combined, natural recruitment and releases may not be sufficient to reach 50 breeding pairs by 2080, 2074, or 2068 for Scenarios 1, 2, and 3. Following strategic habitat conservation planning, the Chihuahuan Desert population is projected to be distributed such that drought or other events impact less than 30 percent of the population over 20 years (moderate condition). Connectivity will be in low condition as the Chihuahuan Desert population will remain >230 miles from other populations. Availability of nesting structures will be in moderate condition under Scenario 1 because yuccas and artificial nesting structures are widely available, and in low condition under Scenarios 2 and 3 because increasing drought durations will continue to impact the principal nest structure (soaptree yucca) and nest builder (Chihuahuan raven). This will increase reliance on artificial nest structures and limit natural nesting structures to those in shrubs or on the ground. Dispersal will be in high condition because the configuration of conserved habitat will ensure that sufficient habitat is available for females to establish breeding territories outside of their natal territory.

Table 6.6. Future conditions for the Chihuahuan Desert population under all future scenarios.

<b>Scenario</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>	<b>Overall Condition</b>
1	Moderate	Moderate	Moderate	Moderate	Low	Moderate	High	Moderate
2	Moderate	Moderate	Moderate	Moderate	Low	Low	High	Moderate
3	Moderate	Moderate	Moderate	Moderate	Low	Low	High	Moderate

### 6.4.3 Tropical Lowlands

Under all future Scenarios, the Tropical Lowlands population is expected to be in an overall moderate condition. Maintaining and conserving greater than 420,000 acres of northern aplomado falcon habitat is considered sufficient to support a population of at least 280 pairs. Maintaining open habitats will provide ample food resources and minimize predation risk, helping to ensure that fecundity and adult survival are sufficient to maintain a stable or growing population. Maintaining live tree fences in pastures will provide adequate tall trees for nesting structures. Coastal and inland habitat will be conserved along at least 700 miles of the Gulf Coast in Mexico, from Tampico to Campeche, to buffer against direct mortality and habitat loss from major hurricanes and rising sea levels. We project that fecundity will be in moderate condition (1.2 and 2 fledglings per territorial pair), breeder survival in moderate condition (0.9 to .092 survival), and abundance in high condition (greater than 50 pairs). The Tropical Lowlands population is projected to be distributed such that hurricanes or other catastrophic events will impact no more than 20 percent of the population every 20 years (high condition). Connectivity will remain in low condition because the Tropical Lowlands population will be >230 miles from other populations. Because stick nests in tall trees with bromeliads are widely available, availability of nesting structures will be in high condition. Dispersal will be in high condition because females will continue to establish breeding territories outside of their natal territory.

Table 6.7. Future conditions for the Tropical Lowlands population under all future scenarios.

<b>Scenario</b>	<b>Fecundity</b>	<b>Breeder Survival</b>	<b>Abundance</b>	<b>Distribution</b>	<b>Connectivity</b>	<b>Nest Site Availability</b>	<b>Dispersal</b>	<b>Overall Condition</b>
1	Moderate	Moderate	High	High	Low	High	High	Moderate
2	Moderate	Moderate	High	High	Low	High	High	Moderate
3	Moderate	Moderate	High	High	Low	High	High	Moderate

Table 6.8. Overall conditions of northern aplomado falcon populations, currently and under Future Scenarios 1 through 3 for the Coastal Texas, Chihuahuan Desert, and Tropical Lowlands populations.

<b>Population</b>	<b>Current Condition</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>
Coastal Texas	Low	Moderate	Moderate	Moderate
Chihuahuan Desert	Low	Moderate	Moderate	Moderate
Tropical Lowlands	Moderate	Moderate	Moderate	Moderate

## 6.5 Future Redundancy

Under future scenarios 1-3, achieving the conservation measures as outlined will increase the species' redundancy from current conditions. Currently, the Coastal Texas and Chihuahuan Desert populations are in overall low resiliency condition, and under each future scenario all populations are expected to be in an overall moderate condition (Table 6.8). The ability for the northern aplomado falcon to repopulate areas within its historical range, from where it has been locally extirpated, will be critical to the recovery of the subspecies throughout its range but especially so for the Chihuahuan Desert population. This population is the most sensitive to the timing of the implementation of conservation measures and occurrence of threats. If conservation actions are not implemented prior to a catastrophic event occurring, the Chihuahuan Desert population could remain in low condition or potentially be extirpated. As described in Current Conditions, there is no known connectivity between the Coastal Texas, Chihuahuan Desert, and Tropical Lowland populations. The loss of this Chihuahuan Desert population would have a significant adverse impact on species redundancy.

Improving redundancy will require active management to protect and grow the Chihuahuan Desert and Coastal Texas populations. For these populations, greater habitat protection, restoration, or enhancement efforts are needed to reduce the observed and projected loss of habitat in all three future scenarios. For example, watershed protection strategies, grassland restoration and conservation, including addressing invasive plant species and brush encroachment, and development and implementation of strategic livestock grazing on publicly managed lands are needed. Additionally, establishing and maintaining effective partnerships for habitat protection and enhancement on privately owned lands will facilitate protection of northern aplomado falcon habitat and reduce further habitat loss. In southern New Mexico, eight northern aplomado falcon suitable habitat areas were identified in La Tierra (2022, p. 3-4). Protecting these would provide greater resiliency and future redundancy for the Chihuahuan Desert population. Although not currently occupied, these areas were historically occupied and/or currently contain suitable habitat.

Population redundancy will continue to be a focus of recovery through the stabilization and restoration of multiple breeding populations throughout the range of the falcon to minimize impacts to the entire subspecies from catastrophic events. In the event that one of the three extant populations is extirpated, it may be possible to utilize captive breeding and release, and/or translocations to reestablish the lost population. However, prior to the implementation of additional captive breeding and releases or translocations of wild birds, aggressive habitat protection efforts are needed in both the U.S. and Mexico. Captive breeding and releases resulted in the successful reestablishment of the Coastal Texas population. Although the same breeding and release protocols were implemented for the Chihuahuan Desert population in the U.S., reestablishment was not successful. Multiple factors, such as genomic differences, disease, and drought may have negatively influenced the survival of released birds. Initial research on northern aplomado falcon genetic diversity suggests that genomic differences exist between the Chihuahuan Desert and other populations. Further research on northern aplomado falcon genomics is needed and would inform future captive breeding and release strategies.

## 6.6 Future Representation

Under future scenarios 1-3, achieving the conservation measures as outlined will secure species representation at current levels. The northern aplomado falcon may have reduced genetic diversity compared to historical levels. In coastal Texas, the species became exceedingly rare following the 1930's (Hector 1987, p. 384), and the abundance of northern aplomado falcons in the Chihuahuan Desert experienced substantial declines; there are now likely fewer than 20 breeding pairs between the U.S. and Mexico (see section 3.3.2 Chihuahuan Desert above). Further, the Chihuahuan Desert population is sensitive to the timing of implementation of conservation measures and the occurrence of threats. If conservation actions are not implemented prior to a catastrophic event occurring, genetic and ecological representation could be negatively impacted.

As described in section 5.3.3 (current representation), we consider the Coastal Texas population to be genetically redundant to the Tropical Lowland population. The Chihuahuan Desert population that primarily exists only in the State of Chihuahua, Mexico is considered genetically distinct from those in the Tropical Lowlands (Johnson and Stock 2017, p. 9). Early efforts to reintroduce captive-bred falcons into southern New Mexico and west Texas desert grassland habitat were largely unsuccessful. This may have been, in part, the result of significant genomic differences between the captive populations source (Tropical Lowlands population) and the Chihuahuan Desert population. The genomic differences may have been sufficient, such that released birds were not capable of thriving or adapting to the different environmental conditions in the Chihuahuan Desert compared to those in the tropical lowlands. The reintroduction efforts carried out from 2002 to 2012 also occurred during a significant drought period, which was cited as a key factor in preventing the successful establishment of the falcon in the Chihuahuan Desert (Hunt *et al.* 2013, p. 344). Additionally, the initial detections of West Nile Virus in Texas, New Mexico and northern Mexico occurred in 2002 (McLean 2006, pp. 46, 49). This coincided with these releases and could have been both a direct and indirect factor in the lack of successful survival and territory establishment through mortality of falcons, their prey species and nest-building corvid species. A catastrophic event occurring before sufficient conservation for the Chihuahuan Desert population is implemented could limit our ability to retain current ecological representation. If genomic differences played a substantive role in the failure of releases to result in successful population establishment in the Chihuahuan Desert, the current captive population may not possess the adaptive capacity to persist in the Chihuahuan Desert, and continuing drought conditions would further limit the ability of released birds to survive.

Research is currently being conducted in Mexico to improve our knowledge of the genomic differences between the Tropical Lowlands and Chihuahuan Desert populations. This will be vital to any effort to revive and reestablish a stable breeding population in the Chihuahuan Desert. If sufficiently diverse alleles occur between these two populations (Chihuahuan Desert and Tropical Lowlands) and new captive breeding and release efforts are attempted, it may necessitate the release of falcons sourced from the population in the Chihuahuan Desert. This would help conserve the Chihuahuan Desert population and improve representation through the enhancement of this third representative population within the historical range of the falcon. Notwithstanding the above, to better address representation, efforts should be made within the next few years to establish a captive breeding program consisting of only Chihuahuan Desert

population falcons to not only enhance existing populations, but to provide for any reintroduction efforts elsewhere within suitable habitats within the historical desert range of the falcon.

## **6.7 Conclusion**

In this SSA, we examined the biology, resource needs, stressors, and current population conditions of the northern aplomado falcon in their naturally occurring range in coastal Texas, Chihuahuan Desert, and tropical lowlands in Mexico. We assessed the future viability of the northern aplomado falcon by applying three plausible future forecasts to the concepts of resiliency, redundancy, and representation. These future scenarios provide an understanding of potential future condition of the species and its habitat.

As discussed here, each of these populations face different levels of risk into the future, but all share to varying degrees the effects of habitat loss or alteration which are further exacerbated by changes in climatic conditions. Aggressive habitat protection efforts are needed to ensure increased population resiliency and maintain or improve levels of species redundancy and representation under each scenario. Since much of the Chihuahuan Desert grassland habitat in southern New Mexico is on federal and state land, including military installations, BLM, National Park Service and State Parks, significant habitat protection could be achieved primarily from effective federal and state regulations on the use of these lands that include sufficient protective measures. This could potentially protect a significant portion of approximately 21.7 million acres of federal and 8.5 million acres of state habitat for the Chihuahuan Desert population in the U.S. Since most habitat in west Texas is on private land, additional protective measures could be established there through voluntary agreements with willing private landowners through various existing federal or state conservation programs. Within the Chihuahuan Desert in Mexico, the majority of potential habitat occurs on privately owned lands. Therefore, working with private landowners to conserve habitat and minimize agricultural conversion as well as develop and implement strategic livestock grazing to minimize impacts to habitat will increase resiliency of the Chihuahuan Desert population (SEMARNAT 2018, p. 28). Restoring, protecting, and maintaining open grassland habitats and other suitable habitats along 200 miles of the Texas coast from Matagorda Peninsula to northern Tamaulipas will improve resiliency of the Coastal Texas population. For the Tropical Lowlands population, efforts to maintain the current distribution and amount of habitat and develop and implement actions to minimize threats to survival such as pesticide use will improve resiliency for this population. Improving resiliency of these populations will help to secure redundancy and representation for the northern aplomado falcon.

## **7 LITERATURE CITED**

- Abatzoglou, J. T. and C. A. Kolden. 2011. Climate change in western US deserts: potential for increased wildfire and invasive annual grasses. *Rangeland Ecology & Management* 64:471–478.
- Albright, T.P., A.M. Pidgeon, C.D. Rittenhouse, M.K. Clayton, B.D. Wardlow, C.H. Flather, P.D. Culbert, and V.C. Radeloff. 2010. Combined effects of heat waves and droughts on avian communities across the conterminous United States. *Ecosphere* 1(5):1-22.

- Baez, S. and S.L. Collins. 2008. Shrub invasion decreases diversity and alters community stability in northern Chihuahuan Desert plant communities. *PLoS ONE* 3(6): e2332:1-9.
- Bendire, C. 1892. Life histories of North American birds with special reference to their breeding habits and eggs. United States National Museum. pp.306-307.
- Bent, A.C. 1937. Life histories of North American birds of prey (part 2) orders Falconiformes and Strigiformes. United States National Museum. pp.96-99.
- Bergmann, C., 1847. Über die verhältnisse der wärmeökonomie der thiere zu ihrer grösse. *Gött. Stud*, 1, pp.595-708.
- Blake E.S, C.W. Landsea, and E.J. Gibney. 2011. The deadliest, costliest, and most intense united states tropical cyclones from 1851 to 2010. NOAA Technical Memorandum NWS NHC-6: pp. 49
- Bock, C.E., J.H. Bock, K.L. Jepson and J.C. Ortega. 1986. Ecological effects of planting African lovegrasses in Arizona. *National Geographic Research*. 2(4): 456-463.
- Bock, C.E. and J.H. Block. 2005. Fire and birds in the southwestern United States. *Studies in Avian Biology* 30:1. pp. 4-8.
- Bodner, G.S. and M.D. Robles. 2017. Enduring a decade of drought: Patterns and drivers of vegetation change in a semi-arid grassland. *Journal of Arid Environments*. 136:1-14.
- Brooks, M.L. and D.A. Pyke. 2002. Invasive plants and fire in the deserts of North America. Pages 1-14 in: K.E.M. Galley and T.P. Wilson (eds.). *Proceedings of the Invasive Species Workshop: the role of fire in the control and spread of invasive species. Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management*. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL.
- Brown, J. L., A. B. Montoya, E. J. Gott, and M. Curti. 2003. Piracy as an important foraging method of Aplomado Falcons in southern Texas and northern Mexico. *Wilson Bulletin* 115 (4):357-359.
- Brown, J.L., M.W. Collopy, E.J. Gott, P.W. Juergens, A.M. Montoya, and W. Grainger Hunt. 2006. Wild-reared aplomado falcons survive and recruit at higher rates than hatched falcons in a common environment. *Biological Conservation* 131: 453-458.
- Brown, V.R. and S.N. Bevins. 2017. A review of virulent Newcastle disease viruses in the United States and the role of wild birds in viral persistence and spread. *Veterinary Research*. 48:68 15pp
- Brown, J.L. and M.W. Collopy. 2008. Nest-site characteristics affect daily nest-survival rates of northern aplomado falcons (*Falco femoralis septentrionalis*). *The Auk*. 125(1): 105-112.
- Bruyere, C.L., R. Rasmussen, E. Gutmann, J. Done, M. Tye, A. Jaye, A. Prein, P. Mooney, M. Ge, S. Fredrick, P. Friis-Hansen, L. Garre, V. Veldore, and J. Niesel. 2017. Impact of

- climate change on Gulf of Mexico hurricanes. NCAR Technical Notes. NCAR/TN535+STR. Boulder, Co. 158 pp.
- Buffington, L.C. and C.H. Herbel. 1965. Vegetational changes on a semidesert grassland range from 1858 to 1963. *Ecological Monographs*. 35(2): 139-164.
- Bureau of Land Management. 2018. TriCounty and Organ Mountains-Desert Peaks National Monument resource management plan and Environmental impact statements\_ baseline socioeconomic report. U.S. Department of the Interior Bureau of Land Management Las Cruces District Office, New Mexico. 100 pp.
- Cade, T. J. 1982. *Falcons of the world*. Cornell University Press. 192 pp.
- Clark, W.S. and Brian K. Wheeler. 1987. *A field guide to hawks of North America*; Peterson Field Guides. Houghton Mifflin Company. Boston, Mass. 198pp.
- Comisión de Áreas Naturales Protegidas. 2013. Programa de Manejo Reserva de la Biosfera de Janos. Secretaría de Medio Ambiente y Recursos Naturales. Mexico D.F. 171 pp.
- Coastal Protection and Restoration Authority of Louisiana (CPRAL). 2017. Louisiana's comprehensive master plan for a sustainable coast. State of Louisiana. 93pp.
- Erickson, W.P., Johnson, G.D., and Young Jr, D.P., 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSW-GTR-191, pp.1029-1042.
- Fink, D., T. Auer, A. Johnston, M. Strimas-Mackey, S. Ligocki, O. Robinson, W. Hochachka, L. Jaromczyk, A. Rodewald, C. Wood, I. Davies, and A. Spencer. 2022. eBird Status and Trends, Data Version: 2021; Released: 2022. Cornell Lab of Ornithology, Ithaca, New York. <https://doi.org/10.2173/ebirdst.2021>. <https://science.ebird.org/en/status-and-trends/species/aplfal/trends-map> and <https://science.ebird.org/en/status-and-trends/species/chirav/trends-map>, accessed July, 2023
- Fleischer, Robert C., B. Slikas and C.E. McIntosh. 1998. Genetic variation in Aplomado Falcons (*Falco femora/is*). Final Report to the Peregrine Fund: 30 October 1998. Molecular Genetics Laboratory, National Zoological Park, Smithsonian Institution, Washington, DC 20008, USA.
- Geo-Mexico. 2011. The Geography of Mexico's Sugarcane Industry. <https://geo-mexico.com/?p=4969>. Accessed April 3, 2025.
- Glover, J. 2017. Reasonable foreseeable development scenario for oil and gas activities in the tricounty study area, south-central New Mexico. USDOJ. BLM. Wyoming State Office Reservoir Management Group.
- Gutzwiller, K.J. and W.C. Barrow Jr. 2003. Influences of roads and development on bird communities in protected Chihuahuan Desert landscapes. *Biological Conservation* 113(2003), pp. 225-237.

- Hager, S.B. 2009. Human-related threats to urban raptors. *Journal of Raptor Research* 43(3).
- Hector D.P. 1981. The habitat, diet, and foraging behavior of the Aplomado Falcon, *Falco femoralis* (Temminck). Oklahoma State Univ. M.S. Thesis.
- Hector, D.P. 1982. Botfly (Diptera, Muscidae) parasitism of nestling aplomado falcons. *Short Communications, Condor* 84: 443-444.
- Hector, D.P. 1985. The diet of the aplomado falcon (*Falco femoralis*) in eastern Mexico. *Condor* 87: 336-342.
- Hector, D.P. 1986. Cooperative hunting and its relationship to foraging success and prey size in an avian predator. *Ethology* 73: 247-257.
- Hector, D. 1987. The decline of the aplomado falcon in the United States. *American Birds* 41:381-389.
- Hicke, J.A., Lucatello, S., Mortsch, L.D., Holsman, K., Conde, C., Froehlich, H., Elias, E.H. and Dukes, J., 2022, March. Intergovernmental panel on climate change working group II sixth assessment report Chapter 14: North America food and fibre. In *Global Climate Change Conference Proceedings*. pp. 1929-2042.
- Hruska, T. 2020. Evolving patterns of agricultural frontier expansion in Mexico's Chihuahuan Desert: a political ecology approach. *Journal of Land Use Science* 15: 270–289.
- Humphrey, R.R. 1974. Fire in the deserts and desert grassland of North America. US Forest Service Publication, Chapter 11: 365-400.
- Hunt, W.G. 1998. Raptor floaters at Moffat's equilibrium. *Oikos*, pp.191-197.
- Hunt, W.G., J. Brown, T. Cade, J. Coffman, M. Kurti, E. Gott, W. Heinrich, J.P. Jenny, P. Juergens, A. Macías-Duarte, A.B. Montoya, B. Mutch, and C. Sandfort. 2013. Restoring aplomado falcons to the United States. *J. Raptor Res.* 47(4): 335-351.
- Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- Intergovernmental Panel on Climate Change (IPCC). 2022. climate change 2022: mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.002.
- Jenouvrier, S. 2013. Review: Impacts of climate change on avian populations. *Climate Change Biology* (2013). Blackwell Publishing. 22pp.

- Johnson, J. and A. Stock. 2017. Temporal analysis of genetic diversity and effective population size of the aplomado falcon (*Falco femoralis*) population in coastal south Texas: Final Report. University of North Texas. 26 pp.
- Johnson, J.A., A. Stock, P. Juergens, B. Mutch, and C.J.W. McClure. 2021. Temporal genetic diversity and effective population size of the reintroduced aplomado falcon (*Falco femoralis*) population in coastal South Texas. *Journal of Raptor Research*. 55(2):169-280.
- Kagan, R.A., T.C. Viner, P.W. Trail, and E.O. Espinoza. 2014. Avian mortality at solar energy facilities in southern California: a preliminary analysis. *National Fish and Wildlife Forensics Laboratory*, 28, pp.1-28.
- Katzner, T., J.A. Johnson, D.M. Evans, T.W.J. Garner, M.E. Gompper, R. Altwegg, T.A. Branch, I.J. Gordon, and N. Pettorelli. 2013. Challenges and opportunities for animal conservation from renewable energy development. *Animal Conservation*, 16(4), pp.367-369.
- Keddy-Hector, D.P. 1988. Vegetative cover, small bird abundance and patterns of aplomado falcon habitat quality in eastern Mexico. Pages 157-164 in: R.L. Glinski, B.G. Pendleton, M.B. Moss, M.N. LeFranc, M.A. Millsap, and S.W. Hoffman (eds). *Proceedings of the Southwest Raptor Management Symposium and Workshop*. Scientific and Technical Series No.11. Institute for Wildlife Research, National Wildlife Federation. Washington, D.C, USA.
- Keddy-Hector, D.P., 2019. The history of aplomado falcon *Falco femoralis* subspecies diagnoses. *Bull. B.O.C.* 2019 139(2): pp. 111-126.
- Keddy-Hector, D.P., D.D.Diamond, and K. Mabrey. 2014. Potential aplomado falcon (*Falco femoralis*) habitat in Mexico. Raptor Research Foundation Annual Meeting. Poster by D. Pursell and K. Mabrey, Mourissi Resource Assessment Partnership, University of Missouri, Columbia, Missouri.
- Keddy-Hector, D. P., P. Pyle, and M. A. Patten. 2020. Aplomado falcon (*Falco femoralis*), version 1.0. In *Birds of the World* (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. <https://doi.org/10.2173/bow.aplfal.01>. Accessed September 2023.
- Kilpatrick, A.M., 2011. Globalization, land use and the invasion of West Nile virus. *Science*. 2011 October 21; 334(6054): 323–327.
- LaDeau, S.L., C.A. Calder, P.J. Doran, and P.P. Marra. 2011. West Nile virus impacts in American crow populations are associated with human land use and climate. *Ecological Research*. 26:909-916.
- La Tierra Environmental Consulting (La Tierra/R. Meyers). 2019. Aplomado falcon survey and monitoring in southern New Mexico, 2018. Report to the Bureau of Land Management. Las Cruces, New Mexico. 70 pp.

- La Tierra Environmental Consulting (La Tierra/R. Meyers). 2020. Aplomado falcon survey and monitoring in southern New Mexico, 2019. Report to the Bureau of Land Management. Las Cruces, New Mexico. 51 pp.
- La Tierra Environmental Consulting (La Tierra/R. Meyers). 2021. Aplomado falcon surveying and monitoring on Fort Bliss, Texas and New Mexico, 2020-2021. Report to Directorate of Public Works, Environmental Division Fort Bliss Training Complex, Fort Bliss, Texas and U.S. Army Corps of Engineers, Tulsa District, Tulsa, Oklahoma. 8 pp.
- La Tierra Environmental Consulting (La Tierra/R. Meyers). 2022. Aplomado falcon survey and monitoring in southern New Mexico, 2021. Report to the Bureau of Land Management. Las Cruces, New Mexico. 68 pp.
- La Tierra Environmental Consulting (La Tierra/R. Meyers). 2023. Aplomado falcon survey and monitoring in southern New Mexico, 2022. Report to the Bureau of Land Management. Las Cruces, New Mexico. 66pp.
- Ladwig, L.M., S.L. Collins, P. L. Ford, and L. B. White. 2014. Chihuahuan Desert grassland responds similarly to fall, spring, and summer fires during prolonged drought. *Rangeland Ecol Manage* 67:621–628.
- Landeros-Sánchez, C., J. C. Moreno-Seceña, L. N. Gavrilov, O. B. Egorova, O. B., and C. Angón. 2011. In: *Impacto de la agricultura sobre la biodiversidad. La biodiversidad en Veracruz: estudio de Estado* (Cruz Angón, A., ed.). Comisión Nacional para el Conocimiento de la Biodiversidad, Gobierno del Estado de Veracruz, Universidad Veracruzana, Instituto de Ecología, A.C. Ciudad de México, México. Pages 477-491.
- Ligon, J.S. 1961. *New Mexico birds and where to find them*. Univ. New Mexico Press, Albuquerque.
- Ludwig, J.A., S.M. Wondsell, E.H. Muldavin, K. Rosalind Blanche, and Y. Chauvin. 2017. Native desert grassland plant species declines and accelerated erosion in the paint gap hills of southwest Texas. *Southwestern Association of Naturalists*. 62(1):53-61.
- Macías-Duarte, A., A.B. Montoya, W.G. Hunt, A. Lafon-Terrazas, and R. Tafanelli. 2004. Reproduction, prey, and habitat of the aplomado falcon (*Falco femoralis*) in desert grasslands of Chihuahua, Mexico. *Auk* 121.:1081-1093.
- Macías-Duarte, A. and A. B. Montoya, C. Méndez-González, J. R. Rodríguez-Salazar, W. G. Hunt, and P. Krannitz. 2009. Factors influencing habitat use by migratory grassland birds in the State of Chihuahua, Mexico. *The Auk* 126(4):896-905.
- Macías-Duarte, A. and Panjabi, A.O., 2013. Association of habitat characteristics with winter survival of a declining grassland bird in Chihuahuan Desert grasslands of Mexico. *The Auk*, 130(1), pp.141-149.

- Macías-Duarte, A., A.B. Montoya, J.R. Rodríguez-Salazar, A.O. Panjabi, P.A. Calderon-Domiguez, W.G. Hunt. 2016. The imminent disappearance of the aplomado falcon from the Chihuahuan Desert. *J. Raptor Res.* 50(2):211-216.
- Macías-Duarte, A., A. O. Panjabi, D. B. Pool, I. Ruvalcaba-Ortega, and G. J. Levandoski. 2018. Fall vegetative cover and summer precipitation predict abundance of wintering grassland birds across the Chihuahuan Desert. *Journal of Arid Environments* 156:41-49.
- Macías-Duarte, A., J. R. Rodríguez-Salazar, N. Hernández Rodríguez, J. A. Alvarado-Castro, O. G. Gutiérrez-Ruacho, and C. I. Ortega-Rosas. 2020. Preventing the Extinction of the Northern Aplomado Falcon in the Chihuahuan Desert: Final Report, State of the Birds Program of the U.S. Fish and Wildlife Service (FWS/R2/ES/F18AP00684). Universidad Estatal de Sonora. Hermosillo, Sonora, Mexico.
- Macías-Duarte, A., A. B. Montoya, J. R. Rodríguez-Salazar, J. A. Alvarado-Castro, and O. G. Gutiérrez-Ruacho. 2021. Natal dispersal of aplomado falcons in Chihuahua, Mexico. *Journal of Raptor Research* 55(2):267-275.
- McLean, R. 2006. West Nile virus in North American birds. *Ornithological Monographs* 2006, No. 60, pp. 46-64.
- McClung, M.R., Nathan T. Taylor, Benjamin K. Zamzow, E. Taylor Stone, Helena Abad, and Matthew D. Moran. 2019. The threat of energy diversification to a bioregion: a landscape-level analysis of current and future impacts on the US Chihuahuan Desert. *Regional Environmental Change* (2019) 19:1949–1962.
- Meyer R.A. and S.O. Williams III. 2005. Recent nesting and current status of aplomado falcon (*Falco femoralis*) in New Mexico. *American Birds.* 59(2): 352-356.
- Montijo-Tautimes, P.T. 2021. *Ámbito hogareño durante el periodo de dependencia del halcón aplomado norteño (Falco femoralis septentrionalis Todd 1916) en Chihuahua, México.* Universidad Estatal de Sonora, M.S. Thesis. 72pp.
- Montoya, A.B. 1995. Habitat characteristics, prey selection, and home ranges of the aplomado falcon in Chihuahua, Mexico. New Mexico State University. M.S. Thesis. 59pp.
- Montoya, A.B., P.J. Zwank, and M. Cardenas. 1997. Breeding biology of Aplomado Falcons in desert grassland of Chihuahua, Mexico. *J. Field Ornith.* 68:135-143.
- Mora, M.A., A.B. Montoya, M.C. Lee, A. Macías-Duarte, R. Rodríguez-Salazar, P.W. Juergens, and A. Lafón-Terrazas. 2008. Persistent environmental pollutants in eggs of aplomado falcons from northern Chihuahua, Mexico, and south Texas, USA. *Environment international*, 34(1), pp.44-50.
- Mora, M. A., C. Baxter, J. L. Sericano, A. B. Montoya, J. C. Gallardo, and J. R. Rodríguez-Salazar. 2011. PBDEs, PCBs, and DDE in eggs and their impacts on aplomado falcons (*Falco femoralis*) from Chihuahua and Veracruz, Mexico. *Environmental pollution* 159, no. 12: 3433-3438.

- Nemeth, N.M., Beckett, S., Edwards, E., Klenk, K. and Komar, N., 2007. Avian mortality surveillance for West Nile virus in Colorado. *The American journal of tropical medicine and hygiene*, 76(3), pp.431-437.
- Oberholser, H.C. 1974. *The bird life of Texas*. Vol. 1, (E. Kincaid, ed.). Univ. Texas Press, Austin. 530pp.
- Paz, S. 2015. Climate change impacts on West Nile virus transmission in a global context. *Phil. Trans. R. Soc. B* 370: 20130561.
- Pearce-Higgins, J. and R.E. Green. 2014. *Birds and climate change: Impacts and conservation responses*. Cambridge University Press. University Printing House, Cambridge CB2 8B • United Kingdom. pp. 103-170.
- Perez, C.J. 1995. Movements, habitat use, and survival of released aplomado falcons at Laguna Atascosa National Wildlife Refuge, Texas. New Mexico State University. M.S. Thesis. 62pp.
- Perez, C.J., P.J. Zwank, and D.W. Smith. 1996. Survival, movements and habitat use of aplomado falcons released in southern Texas. *J. Raptor Res.* 30(4):175-182.
- Petrie, M.D., S. L. Collins, A. M. Swann, P. L. Ford and M.E. Litvak. 2015. Grassland to shrubland state transitions enhance carbon sequestration in the northern Chihuahuan Desert. *Global Change Biology* 21:1226-1235.
- Rolek, B.W., L. Dunn, B. Pauli, A. Macias-Duarte, B. Mutch, P. Juergens, T. Anderson, C.N. Parish, J.A. Johnson, B. Millsap, and C.J.W. McClure. 2022. Long-term demography of a reintroduced population of endangered falcons. *Global Ecology and Conservation*. 38:1-16.
- Sachan, N. and Singh, V.P., 2010. Effect of climatic changes on the prevalence of zoonotic diseases. *Veterinary World* 3(11), p.519.
- Samour, J. 2014. Newcastle disease in captive falcons in the Middle East: A review of clinical and pathologic findings. *Journal of Avian Medicine and Surgery*. 28(1):1-5.
- Schrenzel, M., J. L. Oaks, D. Rotstein, G. Maalouf, E. Snook, C. Sandfort, and B. Rideout. 2005. Characterization of a new species of Adenovirus in falcons. *Journal of Clinical Microbiology* 43 (7), p. 3402-3413.
- Seager, R., T. Mingfang, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H-P. Huang, N. Harnik, A. Leetmaa, N-C. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. *Science*. 316:1181-1184.
- SEMARNAT, 2018. Programa de Acción para la Conservación de la Especie Halcón Aplomado (*Falco femoralis*), SEMARNAT/ CONANP, México (Año de edición 2018).

- Smith, E.H., F. Chavez-Ramirez, L. Lumb, and J. Gibeaut. 2014. Employing the conservation design approach on sea-level rise impacts on coastal avian habitats along the central Texas coast. Final report submitted to Gulf Coast Prairies Landscape Conservation Cooperative. 140 pp.
- Smith, D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, and H.M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. *Journal of Fish and Wildlife Management* 9(1):1-19; e1944-687X. doi:10.3996/052017-JFWM-041
- Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022. Global and regional sea level rise scenarios for the United States: Up- dated mean projections and extreme water level probabilities along U.S. coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp.  
<https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf>.
- Sweikert, L. and M. Phillips. 2011. 2011 Aplomado falcon annual report. Submitted to U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, Albuquerque NM. Turner Endangered Species Fund. Bozeman, Montana. 28 pp.
- Texas Demographics Center. 2022. Texas population estimates and projections program. Accessed February 18, 2022 at:  
<http://demographics.texas.gov/Data/TPEPP/Projections/Index.aspx/>
- Texas Parks and Wildlife Department (TPWD). 1986. Northern aplomado falcon leaflet. Austin, TX. 5pp.
- The Peregrine Fund. 2007. Northern aplomado falcon restoration. 16 pp.
- The Peregrine Fund. 2012. Northern aplomado falcon restoration. Final Report. U.S. Fish and Wildlife Service grant number F12AP00235. 11 pp.
- The Peregrine Fund. 2017. Northern aplomado falcon recovery effort habitat restoration. Final Performance Report. U.S. Fish and Wildlife Service grant number F15AC01043. 6 pp.
- The Peregrine Fund. 2019. Northern aplomado falcon cooperative agreement. Final Report. U.S. Fish and Wildlife Service grant number F17AC01040. 10 pp.
- The Peregrine Fund. 2021. Recovering the northern aplomado falcon. Interim Performance Progress Report. U.S. Fish and Wildlife Service grant number F20AC11482. 61 pp.
- The Peregrine Fund. 2022a. Recovering the endangered northern aplomado falcon. Interim progress report. U.S. Fish and Wildlife Service grant number F21AP00477. 16 pp.

- The Peregrine Fund. 2022b. Northern aplomado falcon populations recovery project. Interim progress report. U.S. Fish and Wildlife Service grant number F19AC00090. 25 pp.
- The Peregrine Fund. 2023a. A population viability analysis for the northern aplomado falcon (*Falco femoralis septentrionalis*). The Peregrine Fund. Boise, Idaho. 4 pp.
- The Peregrine Fund. 2023b. Recovering the northern aplomado falcon. Final Performance Progress Report. U.S. Fish and Wildlife Service grant number F20AC11482. 14 pp
- The Peregrine Fund. 2023c. Aplomado Falcon Release Numbers by Year. The Peregrine Fund, Boise, Idaho. 2 pp.
- Trochet, A., Courtois, E. A., Stevens, V. M., Baguette, M., Chaine, A., Schmeller, D. S., Clobert, J., Irschick, D. J., and Wiens, J. J. 2016. Evolution of sex-biased dispersal. *The Quarterly Review of Biology* 91: 297–320.
- Truett, J.C., 2002. Aplomado falcons and grazing: invoking history to plan restoration. *Southwestern Naturalist*: 47(3) :379-400.
- U.S. Department of Agriculture (USDA) and Global Agricultural Information Network (GAIN). 2022. Report Name: Sugar Annual. MX2022-0027. USDA Foreign Agricultural Service. Washington, D.C. 10pp.
- U.S. Department of Agriculture (USDA) and Global Agricultural Information Network (GAIN). 2024. Report Name: Sugar Annual. MX2024-0020. USDA Foreign Agricultural Service. Washington, D.C. 18pp.
- U.S. Fish and Wildlife Service (USFWS). 1986. Endangered and threatened wildlife and plants; determination of the northern aplomado falcon to be an endangered species. Federal Register. Washington, D.C. 51(37):6686-6690.
- U.S. Fish and Wildlife Service (USFWS). 1990. Northern aplomado falcon recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico 56pp.
- U.S. Fish and Wildlife Service (USFWS). 2014. Northern aplomado falcon (*Falco femoralis septentrionalis*) 5-Year Review: summary and evaluation. New Mexico Ecological Services Field Office, August 26, 2014. Unpubl. Rpt. 46pp.
- U.S. Fish and Wildlife Service (USFWS). 2016a. USFWS memorandum: peer review process. August 2016. 3 pp
- U.S. Fish and Wildlife Service (USFWS). 2016b. USFWS species status assessment framework: an integrated analytical framework for conservation. Version 3.4 dated August 2016
- U.S. Fish and Wildlife Service (USFWS). 2024a. Developing GIS data layers and analysis for northern aplomado falcon (*Falco femoralis septentrionalis*) Species Status Assessment

- (SSA) Chihuahuan Desert Population. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 31pp.
- U.S. Fish and Wildlife Service (USFWS). 2024b. Supplemental spatial analysis: Examining historical and projected land cover change for the U.S. analysis areas for northern aplomado falcon. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 7pp.
- U.S. Fish and Wildlife Service (USFWS). 2024c. Supplemental spatial analysis: Examining Agricultural Growth in the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe of Northern Chihuahua, Mexico. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 10pp.
- Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. *Bioscience* doi: 10.1093/biosci/biu218 1-8.
- Williams, A.P., Cook, E.R., Smerdon, J.E., Cook, B.I., Abatzoglou, J.T., Bolles, K., Baek, S.H., Badger, A.M. and Livneh, B., 2020. Large contribution from anthropogenic warming to an emerging North American megadrought. *Science*, 368(6488), pp.314-318.
- Williams, A.P., Cook, B.I. and Smerdon, J.E., 2022. Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. *Nature Climate Change*, 12(3), pp.232-234.
- Young, K.E., B.C. Thompson, A. Lafon Terrazas, A.B. Montoya, and R. Valdez. 2004. Aplomado falcon distribution and abundance in the northern Chihuahuan Desert of Mexico. *Raptor Research*. 38:107-117.
- Zimmer, C. 1995. How to make a desert. *Discover Magazine*. February, p. 51-56.