Northern aplomado falcon

(*Falco femoralis septentrionalis*)

5-Year Status Review:

Summary and Evaluation

U.S. Fish and Wildlife Service

Texas Coastal and Central Plains Ecological Services Field Office

Corpus Christi, Texas

October 28, 2024

5-YEAR REVIEW

Northern aplomado falcon (*Falco femoralis septentrionalis*)

1.0 GENERAL INFORMATION

1.1 Listing History

Species: Subspecies
Date listed: February 25, 1986
FR citation(s): 51 FR 6686
Classification: Endangered

Critical habitat/4(d) rule/Experimental population designation/Similarity of appearance listing: 71 FR 42298, Establishment of a Nonessential Experimental Population of Northern Apolmado Falcons in New Mexico and Arizona, July 26, 2006

1.2 Methodology used to complete the review:

In accordance with section 4(c) (2) of the Endangered Species Act of 1973, as amended (ESA), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (Service) evaluated the biology and status of the northern aplomado falcon as part of a draft Species Status Assessment (SSA: in review) and announced this status review through a Federal Register notice (87 FR 5834), published on February 2, 2022. During the 90-day comment period of the Federal Register notice, new information about species' biology, habitat conditions, conservation measures implemented, threats, and trends was solicited from Federal and State agencies, tribes, nongovernmental organizations, academia, and the general public. This review was informed through the public review notification, a comprehensive review of documents regarding the northern aplomado falcon available to the USFWS's New Mexico Ecological Services Field Office, Texas Coastal and Central Plains Ecological Services Field Office, Lower Rio Grande Valley National Wildlife Refuge, and information and analyses in the draft SSA. The primary sources of information used in this analysis were the final listing rule (51 FR 6686), the 2014 5-year status review (USFWS 2014), peer reviewed scientific publications, published and unpublished reports, and information elicited from species experts.

Development of the draft SSA report was guided by the SSA Core Team. The SSA Core Team is comprised of species experts from Ecological Services and Refuges Program within the USFWS and the Universidad Estatal de Sonora, Mexico, experts who actively work with the northern aplomado falcon. That team reviewed the SSA report before we used it in the scientific basis to support our 5-year review. The draft SSA report represents our evaluation of the best available scientific information, including the resource needs and the current and future condition of the species.

1.3 FR Notice citation announcing the species is under active review:

87 FR 5834, Endangered and Threatened Wildlife and Planta: Initiation of 5-Year Status Reviews of 35 Species in the Southwest, February 2, 2022

2.0 REVIEW ANALYSIS

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The Act defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether a species meets the definition of "endangered species" or "threatened species" due to any of the five factors described below.

Section 4(a) of the Act describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Service recommends whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

2.1 Distinct Population Segment (DPS) policy (1996):

The northern aplomado falcon is listed as a subspecies and a DPS does not apply at this time. It is not clear if coastal populations of the northern subspecies are discrete from the nominate subspecies. This needs further study to resolve, via genetic evaluations.

2.2 Updated Information and Current Species Status

2.2.1 Biology and Habitat:

In general, little new information about the subspecies biology and habitat is available that was not addressed in the 2014 5-year review, therefore, information in the 2014 5-year review (USFWS 2014, entire) continues to be accurate. New information from the draft SSA on the subspecies biology and habitat are provided below.

There are three populations of northern aplomado falcons, one in coastal Texas, one in the Chihuahuan Desert of the U.S. and Mexico, and one in the tropical lowlands of Mexico. 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). Genetic mixing between populations could occur if they occupied habitat within 230 miles of one another. The populations, however, 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 between known nesting areas. Therefore, there is no known connectivity or genetic exchange between the Coastal Texas, Chihuahuan Desert, and Tropical Lowland populations.

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 Chihuahuan Desert and Tropical Lowlands populations. A more recent genetic survey using 10 DNA microsatellite loci, however, suggests that the falcon population in Chihuahuan Desert has significantly lower genetic diversity compared to those in the Tropical Lowlands (Johnson and Stock 2017, p. 7) and forms a genetically distinct cluster, suggesting 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). 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).

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 subspecies currently ranges from Boca Chica to Matagorda Island, including Padre Island and San Jose Island. Northern aplomado falcons occasionally disperse between these two areas and interbreed. According to Peregrine Fund's Population Viability Analysis Report (The Peregrine Fund 2021, p.35 & 58), fecundity for the population in coastal Texas has averaged 1.72 since 2011 and average annual breeder survival since 1993 is 85 percent. The maximum population size documented in coastal Texas was 44 pairs in 2005 (The Peregrine Fund 2012, p. 9). In 2017, there were 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), quickly reducing the population to 26 pairs (The Peregrine Fund 2019, p. 8). In the 5 years following Hurricane Harvey the number of breeding pairs in the Texas mid-coast increased to 11. However, during that same period, the number of breeding pairs along the Lower Laguna Madre del Norte declined by 9 breeding pairs. Overall, 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 26 pairs (B. Mutch, pers. comm., October 21, 2024).

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). As of 2021, the only confirmed breeding pair in New Mexico is in Luna County (Simpson Draw) south of Deming New Mexico. From 2001-2022, an average of 1.9 young were fledged each year (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). There had been sightings near Otero Mesa in Otero County, New Mexico, and three other nesting attempts observed on the Armendaris Ranch in Sierra County, New Mexico 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 the trans-Pecos region of 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). 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 at Sueco and from 24 to 2 at Tinaja Verde (Macías-Duarte *et al.* 2016, p. 212). Even optimistically, there currently appears to be fewer than 15 breeding pairs in the Chihuahuan Desert population (A. Macías-Duarte, pers. comm., May 5, 2024).

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 the 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. In this focus area, there is some demographic data available for the tropical lowland population, but the subspecies' status there remains nebulous. The population seems secure as the subspecies 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).

Life History: Adult northern aplomado falcons usually occur in pairs and are primarily non-migratory, remaining together as mated pairs year-round in the same territory and tend to exhibit strong nesting territory fidelity (USFWS 2014, p. 6; 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).

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^2 (Montoya *et al.* 1997, p. 138) but more recently, a home range size estimate of 200 km^2 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^2 ($\overline{x}$ = 112 km^2 (Perez *et al.* 1996, p. 177).

Nesting chronology is variable, with primary nesting occurring from February through June in northern portions of the range, and aerial courtship displays being observed as early as late January and early February (Keddy-Hector *et al*. 2020, *accessed* September 2023). In Chihuahua, a fraction of nesting pairs produce a second clutch each year (A. Macías Duarte, pers. comm., May 7, 2024).

Breeding/Nesting Habitat: In Coastal Texas, 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). 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).

Nonbreeder/floater habitat: Although the precise characteristics of habitat used by floaters (nonbreeding 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). 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). 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).

2.2.2 Threats Analysis (threats, conservation measures, and regulatory mechanisms):

In this section, the past, current, and future threats that act on northern aplomado falcons directly, or on their needed resources, and that may affect the subspecies' long-term viability are discussed. Current and potential future threats to the northern aplomado falcon include: 1. Land Conversion (Factor A); 2. Contaminants (Factor E); 3. Woody Encroachment (Factor A and E);

4. Predation (Factor C); 5. Shooting (Factor E); 6. Collisions (Factor E); 7. Climate Change (Factor E); and 8. Disease (Factor C).

1. 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. 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 considered a major stressor.

It is estimated that approximately 758,313 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. 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. 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 historic 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 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 to protect and conserve desert grasslands where aplomado falcons are known to occur in northwestern Chihuahua (Comisión Nacional de Áreas Naturales Protegidas, 2013, p. 17, eBird, A. Macías-Duarte, pers. comm., May 5, 2024); however, cropland expansion remains a threat around the biosphere reserve in spite of the 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. Additionally, 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 resulted in habitat modifications sufficient enough to impact prey species, reducing the ability of northern aplomado falcons to establish territories and successfully breed (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, impairing the ability for northern aplomado falcons to effectively hunt. Intense grazing 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).

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 (USFWS 2024b, pp. 3-5). Future modeling indicates that 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 (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 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 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). 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, 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. Such developments result in the 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 a stressor for falcons in the tropical lowlands. Conversion typically converts forest into grasslands for grazing. This type of conversion could benefit northern aplomado falcons by increasing suitable open habitat (Keddy-Hector *et al*. 2020, accessed September 2023).

2. Contaminants

When the northern aplomado falcon was 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. Since listing, levels of OC compounds have generally decreased in the U.S., but some prey species still show higher levels of OC in the Lower Rio Grande Valley (Mora *et al.* 2008, p. 45). Levels of OC compounds, primarily DDE [1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene], were elevated in northern Chihuahua, Mexico (Mora *et al*. 2008, pp. 48-49) and detected in northern aplomado falcon eggs from coastal Texas, but negative effects on reproductive success were not documented (Mora *et al.* 2008, pp. 48-49). 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 has decreased the level of threat of these compounds (Mora *et al.* 2008, p. 49; Mora *et al.* 2011, p. 3435). Continued monitoring of these

compounds in both the U.S. and Mexico, however, will be necessary to determine if unauthorized use of these pesticides results in impacts to northern aplomado falcons.

Other contaminants of 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).

3. Woody Encroachment

In the United States, woody encroachment into Chihuahuan Desert grassland habitat, primarily resulting from historic livestock grazing practices, is considered to be a significant threat to northern aplomado falcons (Truett 2002, pp. 385-386; Meyer and Williams 2005, pp. 352-355). Increased woody vegetation reduces hunting effectiveness (Keddy-Hector *et al*. 2020, accessed September 2023; Hector 1986, p. 163) and increases habitat conditions that support predators such as great horned owls (Hunt *et al*. 2013, p. 346). Woody plant encroachment into desert grassland habitats in Chihuahua, Mexico may have occurred more recently, allowing the persistence of aplomado falcons in Mexico (Macías-Duarte *et al*. 2004, p. 1090).

Woody encroachment is a current threat to northern aplomado falcon habitat in coastal Texas, secondary to habitat loss resulting from land conversion as described above. Northern aplomado falcons avoid areas with trees, particularly live oak mottes. 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. These areas 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 may have caused the abandonment of historic nesting territories in Veracruz (Keddy-Hector *et al.* 2020, accessed September 2023; A. Macías-Duarte, pers. comm., May 5, 2024).

4. 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 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).

5. 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.

6. 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.

7. Climate Change

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. Climate change is 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 threats (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. 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*. 2014, 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). This dynamic change 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). Extensive drought conditions in the Chihuahuan desert grasslands reduced 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). 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_2 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 even 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 population in coastal Texas.

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 resilient to hurricanes, but this assumption bears further scrutiny.

Climate change is 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 is estimated to be 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 climate change (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 increase 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 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 (Brooks and Pyke 2002, p. 5). In contrast, overgrazing of desert grasslands 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 by consuming nests and killing northern aplomado falcon nestlings, fire is also vital to conserving northern aplomado falcon habitat in coastal Texas. 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, and deep-sand grasslands and gulf cordgrass-dominated prairie. Borrichia or shoregrass (M*onanthochloe littoralis*) dominated communities typically lacks sufficient fine fuels to carry fires and thus, fire tends not to be a stressor in such communities.

Fire serves as an important tool in mitigating shrubland encroachment. A decrease in fire frequency could result in increased woody encroachment, which could negatively affect habitat in the Chihuahuan Desert and coastal Texas. In contrast, an increase in fire frequency in the tropical lowlands creates and maintains open fields which are used by northern aplomado falcons. Thus, altered fire regimes may be a stressor for northern aplomado falcon populations in the Chihuahuan desert grasslands and coastal Texas, but not likely a population-level stressor for the tropical lowlands population because it is considered beneficial.

8. Disease

The frequency and magnitude of the threat 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. 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 21st 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 in west Texas at the height of the West Nile Virus outbreak in Texas (The Peregrine Fund 2007, p. 50.). There is a positive relationship between human development and West Nile Virus transmission (Kilpatrick 2011, p. 12). The effects of climate change 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 expect 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 subspecies' range.

The effect of parasitism on the northern aplomado falcon was not included in our analysis pending the availability of more current or additional data. Hector (1982, p. 443) documented aplomado falcon nests in eastern Mexico infested with *Philornis* flies and was the first known parasite of 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).

We identified two main areas of concern affecting the recovery of the northern aplomado falcon. The first area relates to those caused by anthropogenic factors (i.e., human development or activities). The effects of human activities produce threats relating to disease due to changes within the ecosystem, reduced frequency of fires, contaminants from agricultural activities; but mainly from the adverse effects of land conversions resulting in habitat loss and fragmentation. In some cases, human activities can result in direct mortality including shooting and destruction of nests or eggs. The second area relates to the ongoing effects of climate change which in turn produce threats 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.

2.3 Synthesis:

The status of the northern aplomado falcon has not improved since our 2014 5-year Status Review (USFWS 2014, entire). There are three populations of northern aplomado falcons that occur throughout the subspecies' historical range: one inland population (Chihuahuan Desert) and two coastal populations (Coastal Texas and Tropical Lowlands). These populations occupy a variety of grasslands, shrub-steppe ecosystems, and open habitats within tropical forests (rainforest and dry forest). Because the population in coastal Texas was established through

captive breeding and releases, it is genetically redundant with the source population in the tropical lowlands in Mexico. Although releases of captive-reared falcons also occurred in northern portions of the Chihuahuan Desert in the U.S., the Chihuahuan Desert population is 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. The genetic makeup of the few individuals in the U.S. (New Mexico and west Texas) is uncertain. 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. Although the northern aplomado falcon is wide-ranging, distances between the populations are greater than the greatest documented dispersal distance. There is no known connectivity between the Coastal Texas, Chihuahuan Desert, and Tropical Lowland populations. The breadth of both genetic and ecological diversity of the northern aplomado falcon are at risk.

Following Hurricane Harvey in 2017, the Coastal Texas population fell to an estimated 26 pairs. Currently there are 26 pairs in the Coastal Texas Population. This population has not reached the previous number of pairs documented prior to the hurricane and remains vulnerable to stressors, including major hurricanes, habitat loss and degradation, and direct mortality from predation.

Comprised of fewer than 15 known breeding pairs (1 in New Mexico, up to three in west Texas and fewer than 10 in Mexico), the Chihuahuan Desert population is 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. Probable causes for this low number of pairs 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 climate change, a reduction in potential avian prey and a lack of nesting structures resulting from development, grazing impacts, disease, and altered fire cycles. Additionally, populations of its main nest builder, the Chihuahuan raven, are in decline throughout the subspecies' range (Fink et al. 2022, accessed 2023). While contamination from organochlorine pesticides had been an original concern in listing the subspecies, more recent research has not shown this to be a major concern anymore (Mora et al. 2011, p. 3436).

Although little data is available for the Tropical Lowlands population, it is considered large and widely distributed enough along the coast and inland to be thought somewhat resilient to hurricanes and rising seas. However, research is needed to resolve conflicting observations on its current status and understand demographics, prey availability, and the impacts of threats such as parasitism of nestlings by botfly larvae on this population.

Threats to the northern aplomado falcon and its habitat continue, in particular the potential loss and fragmentation of habitat due to land conversion from development (human growth and energy) and agriculture. Climate change is likely to increase temperatures and periods of drought contributing to reductions in prey species and natural nesting structures, reductions in stick nest builders from disease, and the increased risk of habitat loss from rising sea levels, increased tropical storms and hurricanes, and changes to fire regimes. Woody encroachment into grassland habitats reduces hunting success and increases risk of predation directly affecting the subspecies

through mortality and decreased recruitment rates. The Coastal Texas and Chihuahuan Desert populations exist at low abundance, threats are not sufficiently abated rendering them susceptible to the effects of stochastic and catastrophic events, and additional research is needed to better understand status of the Tropical Lowland population. Additionally, given the recent declines and current low population size of the Chihuahuan Desert population, the breadth of both genetic and ecological diversity of the northern aplomado falcon are at risk. Therefore, the northern aplomado falcon meets the definition of an endangered species and we recommend that it remains classified as endangered.

3.0 RESULTS

3.1 Recommended Classification:

No change is needed

3.2 New Recovery Priority Number:

9C

Brief Rationale:

There are three populations of northern aplomado falcons. The largest, in coastal Mexico, has a low degree of threat. The coastal Texas population is small and has a high degree of threat and the Chihuahuan Desert population is very small with a high degree of threat. Therefore, overall for the subspecies there is a moderate level of threat. The subspecies has a high recovery potential if conservation actions are implemented. Construction and development projects, some associated with economic or energy activity, and land uses, conflict with the subspecies habitat needs.

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: Not Applicable
Reclassification (from Endangered to Threatened) Priority Number: Not Applicable
Delisting (Removal from list regardless of current classification) Priority Number: Not Applicable

Brief Rationale:

Not Applicable

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Protect habitat along a greater stretch of the Texas coastline to facilitate increased distribution of northern aplomado falcons along the coast and increase the Coastal Texas population’s resilience to hurricanes.

Implement conservation measures in coastal Texas to protect potential habitat upslope from development, clear it of woodlands, and maintain it with frequent fire or occasional coastal flooding to allow the population to shift upslope buffering effects of rising seas.

Implement artificial nest structures to offset competition for or limited natural nests in the Chihuahuan Desert and Coastal Texas populations, where needed.

Continue research into genomic differences that will be needed in designing future captive breeding and/or translocation efforts.

When possible, given workloads, draft a revised recovery plan.

5.0 REFERENCES

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.

Baez, S. and S.L. Collins. 2008. Shrub invasion decreases diversity and aAlters community stability in northern Chihuahuan Desert plant communities. PLoS ONE 3(6): e2332:1-9.

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. and J.H. Block. 2005. Fire and birds in the southwestern United States. Studies in Avian Biology 30:1. pp. 4-8.

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. 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.

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.

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, R.C., B. Slikas, and C.E. Mcintosh. 1998. Genetic variation in Aplomado Falcons (Falco femoralis). Final Report to the Peregrine Fund: 30 October 1998. Molecular Genetics Laboratory, National Zoological Park, Smithsonian Institution, Washington, DC 20008, USA.

Glover, J. 2017. Reasonable foreseeable development scenario for oil and gas activities in the tricounty study area, south-central New Mexico. USDOI. 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. 1982. Botfly (Diptera, Muscidae) parasitism of nestling aplomado falcons. Short Communications, Condor 84: 443-444.

Hector, D. 1987. The decline of the aplomado falcon in the United States. American Birds 41:381-389.

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 fFalcons 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., 2019. The history of aplomado falcon Falco femoralis subspecies diagnoses. Bull. B.O.C. 2019 139(2): pp. 111-126.

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.

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.

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 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. Rodriguez-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., 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.

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. Rodriguez-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.

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., 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.

Sachan, N. and Singh, V.P., 2010. Effect of climatic changes on the prevalence of zoonotic diseases. Veterinary World 3(11), p.519.

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.

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.

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. 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.

Truett, J.C., 2002. Aplomado falcons and grazing: invoking history to plan restoration. Southwestern Naturalist: 47(3) :379-400.

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). 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.

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.

Zimmer, C. 1995. How to make a desert. Discover Magazine. February, p. 51-56.

6.0 Personal Communications

Alberto Macías-Duarte, Universidad Estatal de Sonora, Mexico, February 13, May 5 & 7, 2024

Angel Montoya, U.S. Fish and Wildlife Service, February 6 & 13, 2024

Brian Mutch, The Peregrine Fund, May 2, 2023, October 21, 2024

Chris Perez, U.S. Fish and Wildlife Service, June 3, 2024

Jennifer McCabe, The Peregrine Fund, Feb. 13, 2023

Paul Juergens, The Peregrine Fund, May 2, 2023

Tim Anderson, U.S. Fish and Wildlife Service, February 13, 2024

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Northern Aplomado Falcon

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not Applicable

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service, Texas Coastal and Central Plains Ecological Services Field Office

Approve DARRELL WILLIAMS Digitally signed by DARRELL WILLIAMS Date: 2024.11.12 09:17:38 -06'00'