U.S. Fish & Wildlife Service

Management of Conflicts Associated with Common Ravens in the United States

A Technical Review of the Issues, 2023

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Common Raven

Contents

List of Tables

List of Figures

Introduction

In North America, common ravens (*Corvus corax*, ravens), have co-existed with other species in predator-prey relationships that evolved over tens of thousands of years. With the accelerating pace of human-caused modifications to the landscape, these relationships have been disrupted, and raven population trends are no longer dependent on pre-settlement ecological drivers (Kristan and Boarman 2007). Ravens are remarkably adaptable and able to easily exploit resources made available due to human modifications to the landscape and the generated products and waste associated with human settlements (Marzluff and Neatherlin 2006); ravens are synanthropic, closely associated with and benefit from people. Consequently, raven populations in recent decades have increased significantly (Sauer et al. 2017) coinciding with a rise in predator-prey conflicts with other species that are in decline, including species with state and/or federal protections (Coates et al. 2020b). In addition, effects on livestock and nut producers are on the rise, and in some cases raven densities and nesting behaviors pose a risk to human health and safety and are the cause of wildfire threats.

Ravens are protected under the Migratory Bird Treaty Act (MBTA, 16 U.S.C. §§ 703-712), which prohibits the take of protected bird species unless permitted by the U.S. Fish and Wildlife Service (Service). The Service is delegated the responsibility to maintain sustainable populations of species protected by the statute and the authority to develop regulations and permits that allow for the sustainable take of protected species under particular circumstances.

The Service's Migratory Bird Program has determined that increased conflicts with ravens, primarily in the western United States[1], warrant the consideration of a comprehensive strategy to manage them. The Migratory Bird Program developed the Species Conflict Framework[2] (framework, Figure 1) which provides a systematic approach to promote consistent species management and thorough coordination with stakeholders. The framework is designed to identify nonlethal and lethal options that could be implemented to resolve conflicts and the level of lethal take that might be necessary to reduce them. This process is designed to be biologically defensible and to promote efficiency, effectiveness, and transparency.

[1] Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

[2] A Conceptual Framework for Evaluating and Responding to Conflicts with Migratory Bird Species. U.S. Fish and Wildlife Service. 2018.

In adherence to the framework, a Core Team of Service staff and non-Service advisory members comprising other federal agencies (U.S. Department of Agriculture, Department of Defense, Bureau of Land Management, and the U.S. Geological Survey) and states (representing Central and Pacific flyways), was formed to develop a comprehensive approach to raven management using the steps of the framework. This document reflects the input and considerable work of the entire Core Team, and we reached unanimous approval of the general management approach discussed below. This strategy, however, is a Service document and may not reflect the views in every respect of all Core Team members.

Purpose of this document

When the Core Team was assembled, it developed a charter (Appendix A) outlining its process and roles and responsibilities of its members. This charter was approved and signed by the Migratory Bird Program Assistant Director. One of its guiding principles is to "develop a large-scale strategy for the Service to address and reduce conflicts with ravens that can guide local scale decisions."

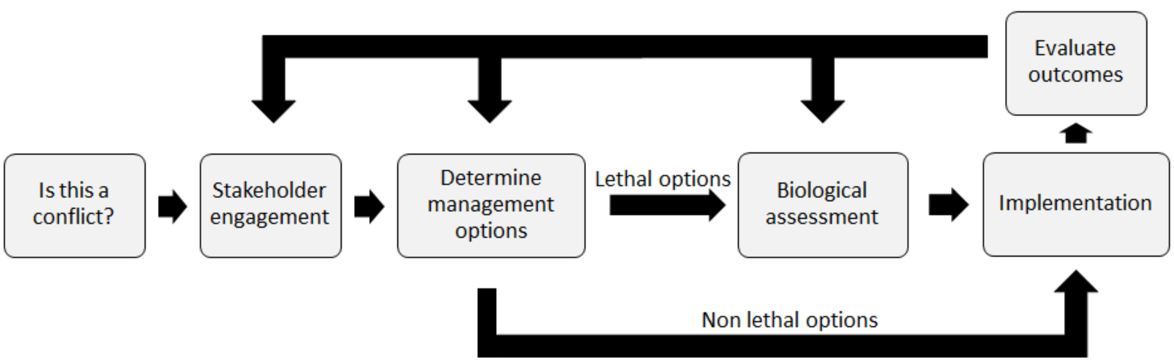

Figure 1: Conceptual framework for addressing conflicts with migratory bird species.

This document is that strategy. It includes a technical review describing raven natural history and their population status, conflicts with wildlife, agriculture, and other resources, and the implications of high raven densities on our nation's resources. It also includes management options under various regulatory mechanisms, and describes nonlethal and lethal management options, monitoring recommendations, and future research needs. It is the Service's hope that this strategy document might guide agencies in a strategic and cooperative effort to reduce raven densities, and, consequently, their impact on wildlife, agriculture, and infrastructure.

Raven Populations and Biological Implications

Another guiding principle of the Core Team charter is to "Articulate the conflict(s) and factors (e.g., biological, anthropogenic) contributing to the conflict(s)." Achieving this guiding principle requires in-depth analyses of existing literature and resources, requesting additional helpful information from stakeholders and tribes, and identifying gaps in information. Below is such an analysis, addressing the many factors the Core Team has determined are contributing to conflicts with ravens in the U.S.

Raven Population Trends

The 50-year raven population trend estimated for the U.S., using Breeding Bird Survey data, has increased 2.87% annually (95% credible interval (C.I.) = 2.46-3.26%/yr); the annual rate of increase in the last 10 years is estimated to be 3.46%/yr (95% C.I. = 2.61-4.29%/yr) (Sauer et al. 2017). This trend has resulted in a near doubling of the population in the last 50 years.

Population growth rates also vary between ecoregions (EPA 2021) within the United States and Canada (Table 1). For example, the Great Plains ecoregion has the greatest increases over time, increasing at a rate of 1.068 per year (Coates et al. 2020*a*). The next three ecoregions with the highest mean annual raven population growth rates are west of the Great Plains and include Mediterranean California (λ = 1.058), North American Deserts (λ = 1.039), and N.W. Forested Mountains (λ = 1.038). Of the 15 Level I ecoregions[3], 73% (11/15) demonstrated positive population growth rates, with 8 of those having statistically significant annual population growth rates ranging from 2.5% to 6.8%. Two ecoregions had no detected ravens (Arctic Cordillera and Tropical Wet Forests), one ecoregion had a constant abundance from year to year (Hudson Plain), and one ecoregion had a non-significant decline (Tundra).

Raven Density and Abundance

The most recent and best available estimate of raven population size in the U.S. is 2.5 million individuals (Partners in Flight Science Committee 2020). These estimates were based on data collected from Breeding Bird Survey (BBS) and have assumptions associated with detection probability. While Sauer et al. (2004) have cautioned against the use of BBS data to provide actual population numbers and have described these attempts as misleading, there have been no other means to quantify the U.S. raven population size.

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[3] EPA Ecoregions of North America webpage (Level I ecoregions are defined here as major ecological areas [that] provide the broad backdrop to the ecological mosaic of the continent.)

Table 1: Proportional change in modeled raven abundance, 2018 versus 1966, across Level I ecoregions. Bolded rows are statistically significant increases at $\alpha=0.05$. L. and U. 95% CrI are 95% Bayesian credible intervals.

Ecoregion	Ratio change	L. 95% CrI	U. 95% CrI
Arctic Cordillera	1.0	1.0	1.0
Eastern Temperate Forests	**3.9**	**3.2**	**4.9**
Great Plains	**23.4**	**16.8**	**32.1**
Hudson Plain	0.8	0.3	2.3
Marine West Coast Forest	**3.1**	**2.0**	**5.1**
Mediterranean California	**14.3**	**7.7**	**26.4**
North American Deserts	**6.2**	**4.2**	**9.3**
Northern Forests	**4.6**	**3.4**	**6.0**
N.W. Forested Mountains	**6.0**	**4.0**	**8.8**
Southern Semiarid Highlands	1.9	0.7	5.0
Taiga	1.0	0.4	2.3
Temperate Sierras	**3.5**	**1.7**	**7.6**
Tropical Wet Forests	1.0	1.0	1.0
Tundra	0.8	0.3	2.0
Water	1.1	0.3	3.4

More reliable results have been achieved where estimates have been reported regionally across broad spatial scales based on higher resolution point count data and distance sampling approaches that adjust for imperfect detection. For example, within the Great Basin sagebrush ecosystems, investigations of broad-scale variation in raven densities were made based on > 16,000-point surveys conducted over 10 years. Raven density within the Great Basin, on average, was estimated to be 0.53 per km^2, corresponding to a total abundance of 165,186 ravens (Coates et al. 2020*a*). However, within areas of low to no anthropogenic resource subsidies, raven density estimates were 0.15 per km^2, which may serve as a proxy for a background density (Coates et al. 2020*b*). Currently, distance sampling is being conducted to estimate raven density within the Mojave Desert and Colorado Subunit of the Sonoran Desert of California, Nevada, and Utah, using the standardized point count data collection protocols carried out in the Great Basin (Coates et al. 2020*a*). Spring 2020-point counts conducted in the Mojave Desert and Colorado Desert of California indicate an estimated raven density of 1.43 per km^2 (Holcomb et al. 2021) and 0.78 per km^2 (USFWS unpublished Data) in these two desert ecoregions, respectively.

Anthropogenic Factors Affecting Raven Population Dynamics

Contributing to their success, ravens are omnivorous, opportunistic, and adaptable to human-altered environments; they feed on eggs, birds, small mammals, amphibians, reptiles, fish, insects, carrion (e.g., road-kill), garbage, and crops (Boarman and Heinrich 2020). In many areas of the west, ravens are indicators of human disturbance with abundances elevated near human settlements (Boarman and Heinrich 2020, Kristan and Boarman 2003, Coates et al. 2014*a*, Howe et al. 2014, O'Neil et al. 2018) and in association with agriculture (Engel and Young 1992, Knight and Kawashima 1993, Kelly et al. 2002, Webb et al. 2009, Coates et al. 2014*a*). Coates et al. (2016) found that raven densities were higher in areas associated with livestock production, with the odds of raven occurrence documented to be >45% in areas where livestock were present. In some cases, ravens depredate newly born lambs or calves on livestock ranches (Larsen and Deitrich 1970, Boarman and Heinrich 2020) causing significant economic impact. Supplemental food and water sources such as garbage, crops, road-kills, etc. (i.e., point subsidies), have significantly influenced raven demographic parameters and allowed the raven population to increase rapidly in human-altered areas. In arid ecoregions, increased raven occurrence and resource use is associated with supplemental water (Knight et al. 1998, Boarman and Coe 2002, Hanks et al. 2009, Coates et al. 2016). Raven reproduction and survival are elevated near and related to the degree of use of these anthropogenic resources (Webb et al. 2004, 2011, Marzluff and Neatherlin 2006). There is also evidence supporting the relationship between nest proximity to point subsidies to enhance fledging success as well as reduce interannual fledging success variation (Kristan and Boarman 2007) and juvenile survival (Webb et al. 2004). Additional studies demonstrated that the same relationship exists between the use of point subsidies by ravens and increased survival (Webb et al. 2011, Peebles and Conover 2017).

Ravens also take advantage of human-made infrastructure for roosting (Engel and Young 1992) and/or nesting substrates (White and Tanner-White 1988, Knight and Kawashima 1993, Steenhof et al. 1993, Kristan and Boarman 2007, Bui et al. 2010, Coates et al. 2014*a*, Howe et al. 2014). For example, Coates et al. (2014b) found that ravens have a higher probability of nesting near human-altered and fragmented landscapes and that the probability of raven occurrence was approximately 25% greater within 2.2 km of transmission lines. Another study by Howe et al. (2014) found that ravens in eastern Idaho readily used anthropogenic structures for nesting with 58% of the 82 nests located on transmission poles and an additional 14% on other human-made towers; power poles and other towers provide elevated perching and nesting locations in areas where these features were historically nonexistent or uncommon (Howe et al. 2014). In south-central Wyoming, over 95% of raven nests were found on human-built infrastructure (Harju et al.

2018). Roads have also been found to influence raven demographic parameters significantly. Raven nest productivity increases by nest proximity to roads (Kristan and Boarman 2007) and adult use of roads for foraging (Webb et al. 2011). However, foraging along roads is associated with lower survival (Webb et al. 2011), and juveniles fledging from nests closer to human activities are more likely to die from an anthropogenic source of mortality than a natural source of mortality (Webb et al. 2004).

Effects on Sensitive, Threatened, and Endangered Species

Raven impacts to natural resources, such as sensitive and T&E species, are typically a result of depredation on species' eggs and young. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services (APHIS WS) reports almost $17 million in cooperator/stakeholder damage and loss from 2013-2017 related to raven impacts on sensitive and T&E species. Species reported as being the most negatively impacted by ravens include the Mojave Desert tortoise (*Gopherus agassizii),* California least terns (*Sterna antillarum browni*), least terns (*Sternula antillarum*), western snowy plovers (*Charadrius nivosus nivosus*), piping plovers (*Charadrius melodus*), marbled murrelets (*Brachyramphus marmoratus*), and sage-grouse (*Centrocercus* spp.). Fragmented habitats and small population numbers contribute to the fragility of T&E species, and large numbers of ravens, often as result of the fragmented habitat, can result in depredations, complicating recovery species efforts.

This section describes the effects that ravens have on sensitive species. Coates et al. (2021) provide a more complete overview of raven impacts on sensitive species, and have devised at Raven Impact Index to compare effects among species. The review below is not meant to be exhaustive but rather highlight the main conflicts where ravens depredate sensitive species, and in some cases contribute substantially to the overall decline of these species. The effects of ravens on some species have been studied extensively, while the data are less complete for others. Even for relatively well-studied cases, e.g., ravens depredating desert tortoise, the story told from the compendium of studies is incomplete. Nonetheless, the weight of evidence points to common ravens as an over-abundant effective predator that is having population-level effects on some sensitive species.

Greater Sage-Grouse

Sage-grouse (*Centrocercus* spp.) are sagebrush obligates (Patterson 1952, Braun et al. 1976, Connelly et al. 2000, Connelly et al. 2004, Miller et al. 2011) and only occur within the sagebrush (*Artemisia* spp.) ecosystem of the western United States and Canada. There are two species: greater sage-grouse (*C. urophasianus*), which occupy 11 states and two Canadian provinces (Alberta, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, Saskatchewan, South Dakota, Utah, Washington, and Wyoming), and Gunnison sage-grouse (*C. minimus*), which occurs in the Gunnison Basin and other isolated areas in southwestern Colorado and one small area in southeastern Utah.

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952, Connelly et al. 2004, Connelly et al. 2011, Wisdom et al. 2011). Sagebrush is considered one of the most imperiled ecosystems in North America due to continued degradation (Knick et al. 2003, Miller et al. 2011, and references therein), and very little extant sagebrush is undisturbed, with up to 50 to 60% having altered understories or lost to direct conversions (Knick et al. 2003). A concurrent decline in the distribution of sage-grouse has occurred (Schroeder et al. 2004). Greater sage-grouse exhibit strong site fidelity to seasonal habitats (i.e., breeding, nesting, brood rearing, and wintering areas) (Connelly et al. 2004, Connelly et al. 2011). Adult sage-grouse rarely switch from these habitats once selected, limiting their ability to respond to changes in their local environments (Schroeder et al. 2020).

Because of their almost complete dependence on sagebrush habitats across landscape scales, sage-grouse are affected by almost any perturbation within sagebrush ecosystems. Large-scale disturbances (e.g., agricultural conversions) within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011) and population persistence (Aldridge et al. 2008, Wisdom et al. 2011). Sage-grouse avoid areas where humans have caused sagebrush fragmentation (Leu and Hanser 2011). The most significant change agents within sagebrush at landscape scales include invasive plant species and their role in altered fire regimes, conifer expansion, oil and gas and other energy development, coal and hard rock mining, transmission lines, cropland conversion, free-roaming horses, and livestock grazing. These threats may be highly impactful at more local scales (Remington et al. 2021).

Numerous population trend analyses for greater sage-grouse have been conducted (see USFWS 2015, Garton et al. 2011, 2015; and Coates et al. 2021). Based on lek count data, these analyses indicate a long-term decline since 1965, with declines flattening in recent years. Concern about declines of sage-grouse led to eight petitions to list the greater sage-grouse throughout all or portions of its range under the Endangered Species Act of 1973, as amended (ESA, 7 U.S.C. § 136; 16 U.S.C. §§ 460 et seq.). In 2015, greater sage-grouse were found not warranted for listing (USFWS 2015). The Bi-State distinct population segment (DPS) of greater sage-grouse along the California/Nevada border was also found not warranted for listing in 2015 (USFWS 2015), but the courts remanded this determination, and the DPS is now undergoing a new review. The International Union for Conservation of Nature (IUCN) red list has listed greater sage-grouse as near-threatened since 2004. Greater sage-grouse were designated a "threatened" species in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1997 and re-designated as endangered in April 1998. The State of Washington listed greater sage-grouse as threatened in 1998.

In a review of demographic rates by 50 studies across the sage-grouse range, Taylor et al. (2012) and Dahlgren et al. (2016) found that female survival and chick survival were the most influential factors on population growth, with nest and chick survival responsible for most of the variation in population growth rates over time. Predation has been identified as the predominant cause of sage-grouse nest failures in some populations (Coates et al. 2008, Bui et al. 2010, Lockyer et al. 2013, Taylor et al. 2017). Sage-grouse are subject to a suite of nest predators consisting of various species of mammals, reptiles, and birds, including common ravens (Schroeder et al. 2020, Coates et al. 2008, Bell 2011, Connelly et al. 2011, Lockyer et al. 2013, Taylor et al. 2017). Several studies have determined that ravens are the most frequent (10 of 17 studies) predators of sage-grouse nests and that ravens appear to cue into the movements of nesting females (Coates and Delehanty 2008, Coates et al. 2008). The relationship between raven numbers and low sage-grouse productivity has been reported, suggesting that sage-grouse nest success is inversely correlated with raven density (Batterson and Morse 1948, Autenrieth 1981). In northeastern Nevada, an increase in one observed raven per 10 km resulted in a corresponding 7.4% increase in sage-grouse nest failure (Coates and Delehanty 2010). In southwestern Wyoming, elevated raven densities were observed in sage-grouse breeding habitat, potentially resulting in reduced nesting success (Bui et al. 2010). An analysis of raven removal resulted in an associated increase in the number of adult male sage-grouse counted on leks the following year (Peebles et al. 2017). Several studies have revealed that sage-grouse actively avoid ravens and other predators during all reproductive stages (Dinkins et al. 2012, 2014). Local attraction of ravens to sage-grouse nesting habitat may be facilitated by the reduction, isolation, and fragmentation of native shrublands that are known to increase exposure of nests to potential predators (Lyon and Anderson 2003, Bui et al. 2010, Coates and Delehanty 2010) and ultimately lower nest success (Vander Haegen et al. 2002, Aldridge and Boyce 2007). Recent evidence suggests that in areas where raven densities exceed 0.40 ravens per km^2 sage-grouse nest survival falls below average (Coates et al. 2020*a*). This density may represent a potential ecological threshold that could help inform the management of ravens in sage-grouse breeding habitat.

Much of the sage-grouse scientific literature reports considerable variation regarding the impacts of ravens on sage-grouse nest survival and productivity (Coates et al. 2020*b*). This variation could potentially be explained through behavioral plasticity of ravens and/or sage-grouse, prey populations, habitat, or a combination of factors (Lockyer et al. 2013). While sage-grouse productivity is expected to be regulated by other threats, such as wildfire and invasive annual grasses at large scales (Schroeder et al. 2020, 2004, Crawford et al. 2004), the continual expansion of the human footprint will likely drive increases in generalist predators such as common ravens (Leu et al. 2008, Knick et al. 2011, O'Neil et al. 2018).

Gunnison Sage-Grouse

Little is known about predation of Gunnison sage-grouse and much of what does exist is anecdotal. However, Young et al. (2020) identified ravens, among other species, as potential predators of Gunnison sage-grouse eggs and chicks. Additionally, researchers reason that Gunnison sage-grouse are subject to similar predation as the better-studied greater sage-grouse (Connelly et al. 2011, Hagen 2011). It is likely that predation acts as a localized threat to Gunnison sage-grouse populations (USFWS 2010, 2014, 2019b). The areas occupied by most Gunnison sage-grouse have experienced long-term stability in numbers and are likely not being impacted by predation (USFWS 2010, 2014). However, studies of the San Miguel satellite population demonstrated that nest predation resulted in reduced recruitment (USFWS 2010) and likely impacts other smaller isolated populations. Because satellite populations are often characterized by greater anthropogenic disturbance, these areas are also likely subject to an increase in abundance of synanthropic nest predators, including ravens (Gunnison Sage-Grouse Rangewide Steering Committee 2005, USFWS 2014).

Mojave Desert Tortoise

Since the late 1980s, researchers in the Mojave and Colorado deserts of the southwestern U.S. have documented precipitous population declines throughout much of the range of the Mojave Desert tortoise (*Gopherus agassizii*) (Berry et al. 1990, Corn 1994, USFWS 1994, Tracy et al. 2004, Allison and McLuckie 2018). Accordingly, in 1989 the USFWS listed the Mojave population of the desert tortoise as endangered under an emergency provision of the ESA. The USFWS then published a final rule listing the Mojave population of the desert tortoise as threatened in 1990 (55 Federal Register 12178–12191). The Mojave population segment of the desert tortoise species inhabits portions of the Mojave Desert as well as the Colorado subunit of the Sonoran Desert that are between 500 and 1500-meters elevation and north as well as west of the Colorado River, in the states of Arizona, California, Nevada, and Utah (Germano et al. 1994). Contemporary genetic techniques have enabled the identification of three distinct desert tortoise species (Edwards et al. 2016*a*, Edwards et al. 2016*b*): the Mojave Desert tortoise, the nominate species of this taxa and the federally listed entity, the Sonoran Desert tortoise (*Gopherus morafkai*), and the thorn-scrub tortoise (*Gopherus evgoodei*).

Unfortunately, listing has done little to stem the disappearance of neonate (0 to 1 years), juvenile (2 to 9 years), subadult (10 to 17 years) and adult (18 to ~39 years) Mojave Desert tortoises. It is estimated that 37% (or approximately 124,000 individuals) of remaining adult tortoises, in critical habitat, were lost between 2004 and 2014. Moreover, the proportional prevalence of neonate and juvenile tortoise observations has also decreased substantially, though the exact percentage is unknown due to low and variable rates of detection (Allison and McLuckie 2018). These declines have been attributed to a range of direct and indirect human-caused impacts, which range from anthropogenically-subsidized predator population expansions and nonnative plant invasions to habitat loss and road mortality (USFWS 2011). Recent evidence further indicates that expansions of the common raven's range and population density are key ecological drivers in the disappearance of young Mojave Desert tortoises across a substantial portion of the Mojave Desert tortoise's range (Kristan and Boarman 2003, Daly et al. 2019, Holcomb et al. 2021).

In accordance with Recovery Objective 1 in the *Revised Recovery Plan for the Mojave Population of the desert tortoise* (USFWS 2011), to maintain self-sustaining populations of the Mojave desert tortoise, state and federal agencies are principally concerned with common raven depredation of zero- to nine-year-old tortoises (i.e., all tortoises with a midline plastron length that is less than or equal to 123.8 mm, assuming a similar growth curve as observed by Medica et al. 2012). This focus was informed by research and observation that linked the increasing number of common ravens to the piles of tortoise carcasses found underneath some common raven nests and feeding perches (USFWS 2008).

After a single spring and fall active period following release of head-started juvenile tortoises into the wild in Mojave National Preserve, 18 of 68 (26.5%) were depredated by common ravens that began nesting nearby. This represents a conservative estimate, given that another 10 (14.7%) of released juvenile tortoises were either lost or could not be assigned unequivocally to a single predator (Daly et al. 2019). In addition, data suggest that even subadult and adult age-size class tortoises are being depredated at an unsustainable rate (personal communication with Collin Richter, University of Georgia, graduate student). A subsequent review of adult tortoise mortality and interaction records revealed multiple common raven attacks on subadult or adult tortoises through the cloaca which usually resulted in death or euthanasia. Reports of adult mortality are on the rise for several Chelonian species (turtles or tortoises); tortoise populations in general are particularly sensitive to additive mortality in adult age-size classes (Moldowan et al. 2021).

Common raven is a natural predator of desert tortoise species, but if annual juvenile survival is suppressed below 0.77 recruitment is expected to functionally cease, thus compromising the generational stability of desert tortoise meta-populations. To estimate the extent to which raven predation suppresses desert tortoise recruitment within the Mojave Desert of California, Holcomb et al (2021) estimated raven density through point counts and deployed desert tortoise decoy depredation trials at randomly placed points throughout Mojave Desert tortoise conservation areas and critical habitat located in the Mojave Desert of California. Common raven density was estimated at 1.43 ravens km^2, (range, 0.63 to 2.44). Survival of the desert tortoise decoys was estimated to be 0.63 (ranged, < 0.42-0.77). A comparison of raven density and annual survival probability of tortoises suggests that common raven densities in excess of 0.89 common raven per km^2 will likely result in an annual survival probability for 0- to 10-year-old desert tortoise that is less than or equal to the historically stable population annual survival probability of 0.77; this is particularly likely when within 1.72 km of a common raven nesting territory. Holcomb et al (2021) conclude that long-term desert tortoise population persistence is highly questionable in every tortoise conservation area in California unless raven densities are reduced to below this threshold.

Western Snowy Plover

The Pacific population of the western snowy plover (*Charadrius nivosus nivosus*) was listed as threatened under the ESA in 1993 (USFWS 1993). The population nests on beaches, gravel bars, and dry ponds along the Pacific coast from Baja California Sur, Mexico, north to Washington. Several studies throughout the range document that ravens are one of the most significant factors negatively affecting breeding success; in some years and at some sites, ravens are the most common predator on plover nests and chicks. Long-term studies along the northern California coast indicate that this population of plovers represents a sink rather than a source population sustained by immigration (Mullin et al. 2010) with ravens causing 70% of known nest failures (Burrell and Colwell 2012). The authors conclude that predator management would improve snowy plover productivity and recovery in the northern California portion of the range. In Oregon, where raven population management has been implemented since 2001, western snowy plover chick survival was much higher than in Washington prior to the establishment of predator management in Washington (Dinsmore et al. 2017). Despite raven removal every year, ravens continue to be a dominant source of predator-caused nest failure for snowy plovers on the Oregon coast (Lauten et al. 2017, USDA 2018). In the San Francisco Bay area, ravens are often the most common avian predator seen during surveys, especially in sites adjacent to landfills or composting facilities. Ravens are also often the most common predator caught on video footage depredating plovers' nests. For example, in 2016 and 2017, the only avian predators caught depredating snowy plover nests on camera were common ravens. In 2015, peregrine falcons (*Falco peregrinus*) and common ravens were the main predators caught on camera depredating plover nests (Pearl et al. 2019, USFWS 2019a). In the Monterey Bay area in 2018, ravens were responsible for 36% of all plover nest losses to predators and 57% of all losses to avian predators. The heaviest nest predation by ravens was concentrated at the Pajaro and Salinas River mouths and adjacent beaches (Neuman et al. 2019).

In some areas, adjacent land-use is attracting ravens to areas near plover nesting sites. For example, agricultural tilling attracts large numbers of ravens to the Salinas River National Wildlife Refuge (NWR) in California. The plovers themselves are probably not numerous enough to attract ravens to the area, but once in the area, ravens also depredate nesting western snowy plovers. Landfills near the Salinas River NWR also attract predators and contribute to increased predator populations (including ravens). Trash left on beaches in snowy plover habitat attracts ravens, which was suspected to lead to depredation of nearby nests (Peterson and Colwell 2014). In the San Francisco Bay area, a composting facility adjacent to snowy plover nesting habitat at the Don Edwards San Francisco Bay NWR routinely attracts large numbers of ravens who forage in the compost. These ravens use the power towers and boardwalk infrastructures of the area as well, for hunting, roosting, and nesting (C. Strong, personal communication).

Greater Sandhill Crane

While not an ESA-listed species, the greater sandhill crane (*Antigone canadensis tabida*) is considered a state endangered species in Washington and California. Studies have documented impacts of nest predation on the Central Valley population (California) of greater sandhill cranes, resulting in considerable loss of nests and young. Impacts from predation have limited nesting success (29 - 44%) in that population (Littlefield 1976, 1995, Stern et al. 1987) to well-below-range averages (77-84%) (Drewien 1973, Bennet 1978). While many species are responsible for depredation of greater sandhill crane nests (Gerber et al. 2020), ravens are one of the most frequently documented. However, researchers in several studies found that higher proportions of crane nests are taken by predators other than ravens (Littlefield 1976, 1995, 1999, 2003, Stern et al. 1987). Furthermore, not all of these studies found evidence of nest predation by ravens (Littlefield and Lindstedt 1992, Ivey and Scheuering 1997). Nonetheless, the ability ravens have to impact low recruitment rates might threaten to declining populations of greater sandhill cranes.

Marbled Murrelet

The marbled murrelet (*Brachyramphus marmoratus*) has been listed under the ESA as threatened since 1992. The 2019 Service 5-year status review of marbled murrelet includes references to raven predation on nests and ravens scavenging eggs taken by other avian predators (USFWS 2019c). In the Redwood National and State Forests, a study found an increased likelihood of ravens locating and predating murrelet nests due to their frequent use of roads and old-growth edges and their overlap in use of the highest parts of the tree canopy (Scarpignato and George 2013). In the Santa Cruz Mountains, 18 of 52 murrelet predation events were attributed to ravens. Lethal management has not reduced raven numbers. Access to anthropogenic subsidies has caused increased raven abundance and associated murrelet nest predation. As part of the intensive management at the Santa Cruz Mountains, the educational "Crumb Clean Campaign", and other methods for reducing human food subsidies in campgrounds are management strategies that appear to have the greatest and most-immediate effect on raven and murrelet populations (Webb 2017). Within Big Basin Redwoods State Park in California, this campaign reduced Steller's Jay density by 85%, and nearly halved the proportion of anthropogenic foods in their diets (Brunk et al. 2021). Steller's Jays are a known predator of Marbled Murrelet in those forests. Population modeling of murrelets in this forest system suggest that a modest reduction in predation might be enough to sustain murrelet populations (Peery and Henry 2010). Thus, in the Santa Cruz Mountains, at least, evidence suggests that reducing food subsidies will be enough to sustain a species of concern.

California Least Tern

The California least tern (*Sternula antillarum browni*) was listed as endangered under the ESA in 1970 and the population nests on beaches and bays along the Pacific coast from Baja California Sur, Mexico north to San Francisco Bay, California. The California least tern is a colony-nesting species. Nesting sites range from more natural sandy beach habitats to dredge spoil sites, urban lots, and runway ovals. Nesting habitat loss and fragmentation have concentrated the remaining colonies into mostly small patches of degraded habitat surrounded by human activity. Nest colonies provide a concentrated food source for predators, and many predators have artificially high population levels around urban areas due to their adaptability to humans, including their ability to exploit garbage and other food sources attributable to humans (Garrott et al. 1993, and Bolger et al. 1997, USFWS 2006).

California least terns' nest on the ground, usually on sandy surfaces of beach or constructed nest sites. Eggs are cryptically colored (Thompson et al. 2020). Despite this crypsis, ravens foraging in nesting areas readily detect and consume the eggs. Ravens can completely wipe out entire colonies. A recent example of how quickly a site can be decimated is provided by the Sweetwater NWR's D Street colony. Between May 23 and

June 2, 2020, a pair of ravens was implicated in the depredation of six nests with eight eggs; all remaining nests (51 nests, with 77 eggs), were depredated by June 7, 2020 (Patton, pers. comm.). In general, managers detect raven depredation based on raven tracks, observations of ravens onsite, observations of least terns mobbing ravens, and by direct observations of ravens consuming eggs or chicks. Since ravens rarely nest in the immediate vicinity of least tern colonies, controlling ravens by managing at their nests presents challenges. Thus, most site managers remove ravens at tern nesting areas.

California least tern nests on the Ormond East Beach (Point Mugu, California) colony experienced severe predation pressure from common ravens and coyotes early in the 2015 season. Ultimately 122 of 173 nests were depredated, the majority between 21 May - 22 June 2015. This colony typically is the largest on the installation but was almost completely abandoned after the first wave of nests was predated. In the same year, the colony at Bolsa Chica experienced 22% nest depredation by ravens. At the same time, no downy chicks (indicating small chicks) were seen on site, and it was assumed that they were also taken by ravens (Frost 2015).

Between 2005-2014 raven predation on California least tern individuals (including eggs) increased substantially. Where depredation was reported by a documented or suspected predator species, state-wide depredation attributed to ravens was 2.4%, 14.5%, and 31.6% in 2005, 2010, and 2014, respectively (Frost 2015, Marschalek 2006, 2011(). While corvid predation is typically intense only at a small number of sites and is usually perpetrated by a few individuals, the loss of only a few tern colonies can have disastrous repercussions on recruitment and population growth (Liebezeit and George 2002).

California Condor

Research has identified excessive adult mortality, not low productivity, as the driver of declines of historical California condor populations (Meretsky et al. 2000). Before 1992, records of successful predation of California condor (*Gymnogyps californianus*) nests were sparse, and few attempts were documented (Snyder and Snyder 2000). Nevertheless, Snyder and Snyder (2000) characterized nest predation by ravens of California condor eggs as the “greatest threat to condor nesting success” while reporting one case of successful nest predation and several attempts at nest predation by ravens. Additional evidence cited by Snyder and Snyder (2000) included California condor eggshell fragments found within several old raven nests. However, since 1992, researchers have only documented a single loss of a California condor egg to ravens. Based on these data, ravens are unlikely to be a significant threat to condor nesting success as described in Snyder and Snyder (2000).

San Clemente Loggerhead Shrike

The San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*) is endemic to San Clemente Island, California. It has been listed under the ESA since 1977 due to its localized range, low population numbers, and consistently low productivity. Habitat degradation and nest predation have both threatened the recovery of the species (Scott and Morrison 1990). Although rarely documented, researchers estimate that nest predation accounts for 44 - 48% of all San Clemente loggerhead shrike nest failures (Yosef 1996, USFWS 2009) and is considered the most significant cause of annual mortality (USFWS 2009). Nest predators have not always been observed, but based on circumstantial evidence of occurrence near nests, punctures in eggs, and predatory behavior, ravens have been cited as potential nest predators (Eggert et al. 2004, Cooper et al. 2005).

Effects on Other Resources

Common ravens can cause a variety of conflicts to both natural and manufactured resources. Resources damaged vary from agriculture (livestock and crops), human health and safety (aviation, disease, fecal contamination, and transporting potentially harmful human waste material outside of landfills), property (utilities, infrastructure, and equipment), as well as natural resources. Raven damage reported to USDA's Wildlife Services program in 2018 was estimated at $5,328,456. From 2014 to 2018, the estimated cost of damage was $15,169,129; however, not all raven damage in the United States is reported to Wildlife Services. Damage costs associated with raven predation to various threatened, endangered, migratory, and upland game birds is often not reported. Most damage by ravens reported to APHIS WS is associated with livestock; in 2018, 77.31% of reported raven-related damage was to agriculture (Peebles and Spencer 2020). Most damage is reported from western states (AK, AZ, CA, CO, ID, MT, NM, NV, OR, TX, UT, WA, WY), but damage in the northeastern (MA, ME, NH, NY, VT) and mid-Atlantic regions (NC, PA, WV) also occurs and is primarily connected to aviation, damage to fruit crops, livestock (fowl), infrastructure, and depredations on threatened and endangered species.

Agriculture (Livestock and Crops)

Raven damage to agricultural resources is reported to occur primarily to livestock and crops. Ravens can depredate, harass, and injure newborn livestock, especially newborn lambs, calves, and goats; often involving mobbing and attacking by multiple birds. Ravens also prey on fowl (chickens, ducks, and turkeys) and their eggs. Livestock loss due to ravens from 2013-2019 was reported to APHIS WS to be nearly $650,000. Producers incur losses from death and veterinary services to injured livestock. Raven predation impacts to captive white-tailed deer have also been reported.

Approximately $1.2 million in damages to crops, primarily from fruit, nuts, and grains by ravens was reported to APHIS WS between 2013 and 2019 (USDA 2021). Ravens can affect ground crops, such as wheat, barley, corn, and oats by picking out seeds. Nuts (almonds, pistachios, pecans) and fruits (grapes, cherries, apples, and blueberries) are also susceptible to raven damage. Irrigation piping and drip lines incur raven damage through pecking, thus preventing water flow to crops.

Human Health and Safety (Aviation, Disease)

Just over $1 million in damage to aviation by ravens was reported to APHIS WS between 2013 and 2019. Aviation damage by ravens is primarily attributed to raven presence on airports resulting in bird strikes (i.e., birds colliding with aircraft) and damage to aircraft. Ravens also cause damage to runways and taxiways by means of pecking and often stripping taxiway and runway infrastructure.

Like other corvids, ravens are carriers of the West Nile virus (WNV), a potentially fatal disease to humans (Northeast Wildlife Disease Cooperative 2020). Mosquitoes serve as a vector, spreading WNV from infected birds to people. Human outbreaks have been correlated with corvid outbreaks of WNV in the same location, though ravens have not been specifically identified (Reisen et al. 2014).

Property (Utilities, Infrastructure, and Equipment)

Raven roosts often occur on or near heated infrastructures (industrial plants or utility structures) and other artificial structures (overpasses, railroad trestles, powerlines, etc.). Power outages on transmission lines, as well as outages that have resulted in rangeland fires and/or loss to power to residents, have been attributed to raven nesting and roosting behavior. Between 2013 and 2019, approximately $11 million in raven damage to property was reported to APHIS WS.

Data Gaps

Common raven population trend data are in hand. The main data gaps are raven density and current abundance estimates. These data are currently lacking across most of the raven distributional boundaries. Desktop analyses can identify areas of concern and can be followed up with a rapid field assessment to determine density and abundance (Coates et al. 2020*b*). Strategically adding several BBS routes in locations without coverage could add to the Service's long-term continental-scale population trend analysis. Changes in density and abundance, as well as overall population trends could be one measure of the efficacy of management. Systematic higher resolution point count data and distance sampling approaches that adjust for imperfect detection could also contribute to addressing data gaps.

Cultural Significance of Common Ravens to Indigenous Peoples

Raven and Alaska Native Cultures - *A brief overview provided by the Alaska Migratory Bird Co-Management Council*

The Common Raven may be a nuisance to some, but to the Indigenous peoples of Alaska, the Raven is many things. He is a trickster, a teacher, a magician, a benefactor, and to some, the creator. Found in myths, poem, and legends, stories with Raven at the center are told on winter evenings, passing on his many adventures and the life lessons that go along with each story. He took on human, bird, and animal forms, and could change at will.

In Southeast Alaska, Raven is one of two major clan groups that identify a person's position based on their mother's membership, signifying the importance of this bird to the Tlingit and Haida people. Raven as a trickster/transformer in Tlingit beliefs is in large part responsible for the characteristics of the natural world that we live in. Through his actions, sun and stars came into existence, the tide was created, freshwater lakes and streams were created, salmon came in from the ocean, and fire was brought to humans for their use. Raven figures are a common and recurring element of Tlingit totem pole art. The picture below is of a Tlingit pole long housed in the Anchorage Museum from Klawock with a Raven prominently positioned at the top of the pole (Figure 2).

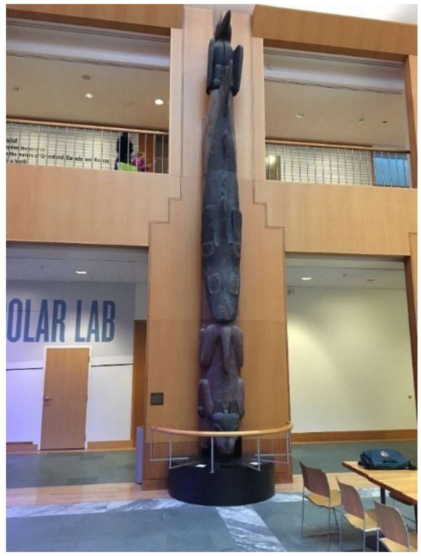

Figure 2: Tlingit pole with Raven positioned at the top.

Raven also plays a very important role in the Athabascan culture, where Raven is believed to have created the world, returned the sun and stars to the sky, and is a benevolent being who helps people and shapes their world for them. They believe, like their neighbors in the Southeast, that he is also a trickster. There are many stories about Raven and his behavior getting him into trouble. One story details how an Ahtna Athabascan chief killed Raven because of all the tricks he played. After he died, the water disappeared from the land and people realized they needed Raven as part of their world, no matter what a trickster he was. So, the chief brought him back to life and the villagers learned how important Raven is to them and the world they inhabit, so they continue to tell this story to teach the younger generations that they should not kill ravens. Among the Ahtna, like the Tlingit, Raven is one of the phratry (major clan) groups to which a person belongs through their mother. The picture below shows the memorial constructed by Ahtna to honor Katie John, a leader who fought for subsistence rights and won a significant case allowing salmon harvesting at traditional locations. The birds represent the Seagull and Raven phratries into which all Ahtna are born and are joined with image of salmon in the memorial (Figure 3).

Figure 3: Memorial constructed by Ahtna; the birds represent the Seagull and Raven phratries.

The same is true in the Yup'ik and Inupiaq cultures. The Yup'ik culture has many Raven stories, including Raven as Creator Bird, Raven and his daughter, and how Raven went on a journey and brought daylight to the Yup'ik people. Why Raven is black and sings with a "caw caw" sound instead of a beautiful call is also explained in stories. How Raven made the Milky Way while he was searching for daylight explains why the heavens at night seem to have a misty covering of snow on them. Regarding killing ravens, the Yup'ik people did not generally hunt them, because they are considered intelligent and wise and can communicate with Yup'ik people. The Inupiaq teach their children to say "Tulugaq Tulugaq naun tutu"[1] – Raven, Raven, where are the caribou? as they believe Raven helps guide them to important subsistence food sources like the caribou. They also teach their children to be kind to the Raven as they can remember many things, and they can be helpful.

Today, old stories are still passed down about Raven, along with new stories detailing current encounters with this mystical bird. Alaska Native Peoples have a connection with this bird, as well as a deep respect. People regularly attend to ravens when they are around. They speak to Raven, feed, and care for him if he is injured, and include him in many aspects of daily living. He is believed to be where he is because that is where he is meant to be. Neither traditionally nor at this time are ravens ever intentionally killed.

It is important to make clear the distinction between Raven as the mythic spiritual being and the ravens that are all around us. Addressing conflicts with the Common Raven is not simply a biological issue with a biological fix. Consideration must be given to Indigenous peoples' world view where Raven is central to their world and is highly respected. Alaska

Native peoples do not see Raven as a nuisance. He is intelligent, tricky, and oftentimes entertaining, but not a nuisance. He is an integral part of the Alaska Native world and should be treated as such when addressing conflicts in the Lower 48 states, and especially in the Pacific Northwest and Alaska.

Raven and Western Native American Cultures

In Southern Oregon and Northern California, the Klamath Tribal culture considers the Raven as very significant. Ravens are listed throughout their oral histories. Ravens are considered a very sacred animal/bird.

The creation story of many Pacific Northwest tribes features the Raven. "*In the beginning, the world was in total darkness*." He was sly and planned to steal the treasure that was All the Light in the Universe. When the chance came, Raven captured the treasure and placed the sun into the sky! (Aves Noir 2010).

Managing Ravens in Partnership with Tribes

Several studies reveal that Ravens, in part because of their cleverness and intelligence long recognized by traditional cultures, have increased as a result of the expanding human footprint, and that increasing numbers of ravens have a detrimental impact on other species. Some of those species, Greater Sage-Grouse for example, also are culturally significant to some Tribes, and the species conflict can raise conflicting views within and beyond traditional cultures. As part of any management solution, the Service promises to consult with tribes over raven management issues, as required by statute, and as a matter of cultural respect and responsibility.

Raven Management Tools

Resolving raven conflicts requires a suite of approaches. These approaches must balance the need for conflict resolution and maintain sustainable populations of ravens for both their biological value and cultural significance.

In this section we describe indirect and direct approaches, including nonlethal and lethal means, of controlling raven numbers. We also describe a logical 5-step approach that managers can use to evaluate raven densities across landscapes of interest, and actions they can take depending on raven densities relative to ecological thresholds of sensitive species. Some methods of raven control require regulatory mechanisms for implementation, while others can be implemented without regulatory oversight.

Ultimately, raven management will require considerable education, outreach, and community action to address human subsidies.

Nonlethal Deterrents

One advantage of nonlethal management is that there is no federal regulatory requirement under MBTA to consider. State laws may not allow these activities without a permit, however, and tribal interests should be considered, as should land-owner access and permissions.

Food Subsidy Removal

Reducing the availability of human-sourced food subsidies is a category of nonlethal management that includes removal of large road-killed animals, reducing access to carcasses in livestock carcass stations, securing and covering garbage cans at roadside stops, restaurants, parking lots, and retail centers, and covering refuse at landfills. The goal of reducing access to food subsidies is to negatively-affect the reproductive potential of ravens nesting within foraging range of these subsidies. Increased competition for food might also lead to emigration by ravens reducing their densities at subsidy locations.

The section on Marbled Murrelets, above, describes efforts to reduce human food sources that led to reduced Steller's Jay densities, which in turn theoretically will help maintain murrelet populations in those landscapes. Steller's Jays have relatively small home ranges and are not as wide-ranging as ravens.

In another study, of ravens and desert tortoise, reducing food subsidies were not successful at reducing densities of a corvid predator. Phases I and II of the 2008 California Monitoring and Management Environmental Assessment were implemented from 2013 through 2021. Nonlethal actions were extensive and included desert-dumping clean-up efforts, installation of wildlife proof dumpsters and receptacles, road-kill removal, public outreach events, K-12 outreach, billboards, buttons, stickers, conservation branding, movie production, and outreach to all municipal waste, water, and compost facilities located within an approximately 24 kilometers of a tortoise conservation area. Additionally, ravens associated with tortoise remains were removed to halt further depredation at these nests. Despite these efforts, the goal of reducing by 75% raven nests was not achieved (USFWS unpublished Data). Point count estimates of raven density in 2020 yielded an average density of 1.56 raven per km^2 (Holcomb et al. 2021).

This case, however, likely points to the need to employ food subsidy removal broadly across the west, and not merely locally. Ravens range widely, and food subsidies in one location may sustain overwintering ravens that then spread to other locations across the west during the breeding season where they might negatively-affect species far from those subsidies.

Hazing

Hazing birds from either nesting, roosting, or foraging areas is another nonlethal technique that might be useful in specific circumstances, though the long-term efficacy of these techniques is not promising. This less than satisfactory effectiveness is largely explained by habituation to solely nonlethal signals. Auditory and visual stimuli can cause avoidance responses in birds and offer temporary protection from damage for a few days or weeks. The effectiveness of frightening and/or hazing devices is often the function of effort and may need to be used more frequently during initial hazing. Hazing techniques to disperse ravens include propane cannons, lasers, scarecrows, pyrotechnics, and flashing lights. Constant harassment may be more effective in dispersing ravens from a localized area. However, birds will likely habituate to areas such as industrial plants and landfills, if the location, timing, and sounds for these devices are not changed frequently. Combining frightening devices with lethal management (i.e., shooting, etc.) may improve effectiveness. The use of these techniques is not likely conducive to highly urban areas, or to areas with sensitive species.

Exclusion

Exclusionary devices, such as spikes and wires, on poles are not effective at preventing raven use. Ravens are known to use such devices as nesting substrate. Placing exclusionary devices or netting on large surface areas found on infrastructure, such as I-beams, lattices, and framework to prevent roosting and/or nesting can also be impractical and costly.

Exclosures have been tried over nests of western snowy plovers but with mixed success in most places. While the exclosures can largely prevent raven predation of nests, the exclosures are visible to predators who can learn to associate nests and the presence of adult birds in/around the nests, contributing to predation of chick and adult plovers by ravens and other predators. In the instance where ravens learn to associate exclosures with available prey, the exclosures themselves can be modified to a trap to catch ravens who have learned this association and are exhibiting this predatory behavior. This was done on Point Reyes Seashore in California where a dummy snowy plover nest was placed inside a modified exclosure with a foothold trap. When the raven was removed, and its carcass placed near occupied exclosures as an effigy it seemed to reduce raven predation for the remainder of the season (Mark Ono, pers. comm., 2021).

Effigies

An effigy is a full or partial representation or likeness of an object. When used properly, effigies can be effective raven deterrents. One study in northern California found that effigies significantly decreased the presence of corvids at a western snowy plover nesting site over the course of four days, suggesting effigies are highly effective for short periods of time at a local scale (Peterson and Colwell 2014). The best kind of raven effigy is a fresh raven carcass, as ravens often peck and destroy artificial effigies. Effigies should be hung upside down from high visibility locations in the area needing protection, with wings outstretched. Locations to hang effigies can include boundary fences, latticework, trees, and/or utility structures when the impact of fire or power disruption is not imminent. It is recommended to place the effigy in a discrete location to avoid observation and/or tampering by the public, when possible. Often the effects of effigies are more successful when coupled with other management techniques, such as hazing (i.e., pyrotechnics, lasers, distress callers, propane cannons, etc.) or shooting. Service permits are needed for the use of effigies created from birds.

Trapping

Trapping ravens and placing a federal band or auxiliary marker on them can aid collecting information on foraging areas, nesting locations, and roost sites to inform management options. A federal permit is required to trap ravens and state permits may be required as well. If ravens are trapped in areas where sensitive species could be affected, extra precautions should be taken to avoid any adverse effects.

Trapping large numbers of ravens is impractical, as ravens do not respond to large communal traps and techniques targeting individual ravens are likely to be more successful. Many types of traps have been tried (Engel and Young 1989, Camp et al. 2013) and each situation will be unique and warrant consideration of different techniques. Trap types have included dho gaza, remotely operated bownets, net launchers, bal chatris, perch snares, with the most common technique the modified padded leghold trap. Traps should be placed in areas that ravens are known to be congregating (i.e., perching areas, near dead animal pits, roadkill, or landfills). Other options are placing traps in known raven flight paths alongside bait, such as road-killed deer or livestock carcasses. Baits should be allowed to be partially eaten by ravens before setting traps. Ravens will typically land away from a carcass and walk to it, so traps should be approximately 4-6 feet away from the bait and concealed and blended with the surroundings. Precautions should be taken to avoid bird injury from the trap and traps checked regularly so that captured birds are not predated. Vegetation, rocks, sticks, and other structures should be used to guide ravens from the bait site to the trap. When raven abundance is low (< 25 birds), trapping is most productive in the twilight hours. When raven abundance is high (> 25 birds), trapping can be conducted throughout the day with high capture probability. Often raven trapping is most successful during winter months when food sources are lower and raven congregations at roost sites, carcasses, and landfills are higher.

Nesting Deterrents

There are a variety of methods that may be used to deter large birds from nesting on power poles (APLIC 2006). Some of these are effective, but others designed as perch deterrents may merely anchor nesting material placed on top (Lammers and Collopy 2010, PacifiCorp 2018). In some cases derelict structures used for nesting may simply be removed. Securing something to the top of a nest, e.g. a traffic cone, will deter some birds from nesting. However, the urge to nest is strong in most pairs, and they will often look for alternative sites when a first, second, or third choice is eliminated. Persistence is required if the option is nest removal.

Nest Removal - Pre-egg Laying

Removing nests before eggs are laid is another technique that may be effective in specific circumstances (Sanchez et al. 2021). In some locations ravens will re-nest if nest removal occurs early in the breeding season, and the operation will need to be repeated for each nest attempt (potentially over several months), until late in the breeding season and the ravens give up. Accessing some nests might be difficult, and determining whether or not the nest has eggs may be a challenge. Nonetheless, this might be an effective short- or long-term solution to reducing raven densities in certain small geographic areas but would be a labor-intensive solution over large areas. This method was used successfully to deter ravens from nesting in power towers over endangered species habitat in the San Francisco Bay area and required coordination with landowners as well as the power company and their lineman staff. Federal and state permits may be required to remove nests. Federal permits are not required if nests do not contain eggs or young.

Taste Aversion

Taste aversion conditions avoidance behavior in predators after being exposed to prey items that have been treated, usually with a chemical emetic (induces vomiting) that causes predators to become ill within minutes of consumption. Carbachol and methiocarb have been tested at reducing raven predation on nests (Avery et al. 1995, Brinkman et al. 2018). Methiocarb was tested on California least tern colonies (Avery et al. 1995). This technique was effective if treated eggs were placed prior to terns nesting, with replacement every three days. Once the least terns were nesting, it was less effective because the odds of the ravens eating a treated egg was greatly reduced as there were so many tern eggs to eat. Effectiveness is likely increased when a colony is within the territory of resident ravens. This method is labor-intensive but could take the place or be integrated into current ongoing predator management for terns and plovers.

Lethal Management

Lethal techniques involve the purposeful killing of ravens. Killing (i.e., take) of birds is prohibited under the MBTA, unless a permit is obtained from the Service. State permits might be required as well, and as with any method of raven control, tribal interests should be considered, as should land-owner access and permissions. Permits and other regulatory mechanisms are discussed under *Regulatory Considerations and Tools* below. There are multiple lethal techniques that may be effective in certain situations. Lethal removal of ravens using the methods described in this section can be effective management tools but should be used once nonlethal methods have been exhausted and should be used in conjunction with nonlethal methods.

Nest Removal - Post-egg Laying

Removing nests after eggs are laid is another effective technique. As with nest removal prior to egg laying (above), a pair might re-nest if nest removal occurs early in the breeding season and thus, might need to be repeated. An advantage to waiting until eggs are laid and incubated for some time before nest removal is that it potentially lengthens the interval between field visits, reducing agency costs. A disadvantage is that the pair will still forage in the area during this period. Removal of nests with young is also a lethal management technique, but nest removal actions should occur prior to hatching to increase effectiveness; energy demands of a pair provisioning young will be higher and damage to wildlife resources will be greater if nests are allowed to hatch.

Egg-oiling

Egg-oiling involves applying a coating of lightweight, cooking-grade oil to raven eggs via a remote spray mechanism or with a handheld sprayer during early stages of egg development. Egg-oiling methods can include using a hand-held spray bottle, a pole-mounted sprayer and camera system, or using drones outfitted with a spray system and camera. The latter technique may be promising when accessing nests by other means is difficult. Once oil-coated, gas exchange through the shell ceases and, thus, the raven embryo fails to develop. Adults will often continue to incubate the clutch of oiled eggs as normal or sometimes well beyond the normal incubation period, which reduces the likelihood that pairs of ravens will re-nest within the season; although the pair will still forage in the area during incubation, their energetic needs are comparatively less than if they were provisioning young. After nest failure, the pair may abandon the immediate territory and emigrate to locations where food is more easily obtained (Harju et al. 2018).

Shooting

Depredation permits issued by the Service requires the use of non-toxic/non-lead ammunition and state that ravens cannot be decoyed, called, or coaxed to damage sites for removal. Non-lead shotgun shells can be effective for removing ravens at close distances (<150 feet). Larger steel or other non-lead ammunition (i.e., bismuth, tungsten, etc.) shot sizes of 2, 4, 5, and 6 are recommended. Ravens are intelligent and learn to stay out of shotgun range or other human activity, thus centerfire rifles loaded with non-lead ammunition can be an effective method for targeting ravens at long distances. Shooting is not recommended for reducing large numbers of ravens at a given time and is unfeasible in highly urbanized areas.

DRC-1339

DRC-1339 (also known as 3-chloro-4-methylanine hydrochloride) is a slow-acting avicide and the only legal toxicant currently registered by the U.S. Environmental Protection Agency (EPA) for use with ravens. DRC-1339 products are restricted-use pesticides and are available only for use by APHIS WS personnel or others under their direct supervision. Depending on the EPA label being used for the application, the pesticide consists of 97% active ingredient powder mixed with warm potable water that is injected into egg or meat cube baits. Other bait items can be used pursuant to the appropriate EPA label. Ravens are highly sensitive to the effect of DRC-1339, and a lethal dose causes a period of listlessness, followed by unconsciousness and ultimately death within 1-3 days, presumably from kidney failure. Ravens have been known to travel many miles from a DRC-1339 treatment site to a roost site. DRC-1339 may be used to control ravens in many different locations, including (and in accordance with label restrictions): range and pasturelands, refuges to protect threatened or endangered species, near sileage or fodder bags, at landfills, and near utility poles or other towers that support nests. Prior to applying DRC-1339 baits, treatment sites should be monitored for evidence of non-target activity and pre-baited to entice raven consumption. Impacts to other species can occur, so careful placement and monitoring of bait is imperative.

Common Raven Take

The Service must authorize any raven take (i.e., lethal removal of adults, chicks, or eggs, and possession of birds or nests) through the depredation, special use – utility, special purpose miscellaneous and scientific collection permitting process. The amount of take varies state-to-state and year-to-year. In the western U.S., a maximum of 20,404 ravens were authorized in any single year, which was in 2014. A maximum of 8,007 were reported as actual take in any single year (2013) within the Pacific Flyway states, from 2006-2017 (Table 3). For the Central Flyway states, a maximum of 2,520 were reported as actual take in any single year (2018), from 2009-2019 (Table 4).

Table 2: Authorized and actual raven take in Pacific Flyway states 2006-2017.

	Arizona		California		Idaho		Nevada		Oregon		Utah		Washington		Sum	Sum
Year	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual
2006	370	82	1465	877	170	114	2620	2384	900	246	17	0	281	3	5823	3706
2007	370	72	1792	1066	170	78	2820	523	900	133	15	0	268	2	6335	1874
2008	510	92	1897	1007	170	109	2170	2201	1195	513	50	1	250	1	6242	3924
2009	380	90	1506	839	170	42	2140	1797	890	360	1400	532	256	10	6742	3670
2010	100	88	549	492	25	3	1810	150	915	265	45	13	250	25	3694	1036
2011	278	48	2627	1248	845	103	4086	3062	2764	281	2105	1515	1199	118	13904	6375
2012	314	163	1966	748	275	193	3810	3287	90	801	2501	2169	250	69	9206	7430
2013	666	152	3316	724	25	9	4540	4209	995	678	2573	2070	32	165	12147	8007
2014	455	111	4057	967	1974	97	4383	4184	540	330	3504	1911	474	266	15387	7866
2015	385	169	2941	610	1775	650	4450	3423	415	228	313	83	219	47	10498	5210
2016	199	157	2435	852	25	230	5150	4189	515	628	2631	979	1019	106	11974	7141
2017	195	173	1484	511	575	52	5197	2148	1138	353	2736	1212	565	257	11890	4706
Average	352	116	2170	828	517	140	3598	2630	938	401	1491	874	422	89	9487	5079
Max	**666**	169	**4057**	1249	**1974**	650	**5197**	4209	**2764**	801	**3504**	2169	**1199**	266	15387	8007
Sum of max Authorized (in bold) = **19,361**																
Data from the Service's *Service Permit Issuance and Tracking System* database; includes take of adult ravens under scientific collecting and depredation permits.																

Table 3: Authorized and actual raven take in the Central Flyway states 2009-2019.

	Colorado		Montana		North Dakota		South Dakota		Wyoming		Sum	Sum
Year	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual	Auth	Actual
2009	548	201	220	40	15	0			1618	259	2401	500
2010	648	285	280	114	5	-			1800	294	2733	693
2011	1001	337	350	132	15	0			1830	316	3196	785
2012	1131	219	355	77	15	0			1990	33	3491	329
2013	1180	22	505	281	15	0	10	0	3090	863	4800	1166
2014	957	26	595	212	15	0	10	0	3440	947	5017	1185
2015	265	50	615	98	10	0	10	0	3520	1002	4420	1150
2016	430	43	800	16	15	0	10	0	3122	1671	4377	1730
2017	455	44	760	75	15	0	10	0	5360	1199	6600	1318
2018	450	35	685	183	15	0	10	0	3545	2302	4705	2520
2019	645	30	685	29	10	0	20	0	4565	1377	5925	1436
Average	701	117	532	114	13	0	11	0	3080	933	4333	1165
Max	**1180**	337	**800**	281	**15**	0	**20**	0	**5360**	2302	6600	2520
Sum of max Authorized (in bold) = **7375**												
Data from the Service's Service Permit Issuance and Tracking System database; includes take of adult ravens under scientific collecting and depredation permits.												

In the eastern U.S., the Service has authorized less raven take overall. In the eastern states (Maine, New Hampshire, Vermont, New York, Connecticut, Rhode Island, Massachusetts, Pennsylvania, Virginia, West Virginia, Maryland, Delaware, and North

Carolina), a total of 76 permits were issued between 2017 and 2019 resulting in the authorized take of 1,009 ravens. In addition to the take of birds, the Service authorized the take of 260 raven nests (with eggs) on 9 permits over the same period.

Regulatory Considerations and Tools

Currently, ravens are covered under the MBTA which protects them from intentional killing or injury, and from the possession, sale, or trade of their nests, eggs, or parts. Various regulatory mechanisms exist under the MBTA that allow for taking ravens, (e.g., depredation permits). Additional regulatory mechanisms could be developed in the future that would authorize raven take (e.g., depredation order). Existing and potential future regulatory mechanisms that authorize raven take are discussed below.

Scientific Collecting Permits

Under 50 CFR 21.73, the Service may issue permits to persons to "... take, transport, or possess migratory birds, their parts, nests, or eggs, for scientific research or educational purposes." Scientific collection permits might be issued by the Service if, for example, a researcher submits a permit application with a proposal for a study to determine whether or not removing ravens from an area might benefit other species in that area. Dietary studies can be implemented through this permit type as well.

Depredation Permits

Under 50 CFR 21.100 the Service may authorize taking birds for depredation control purposes, that is, for the "... protection of crops or other interests." This is the most common federal regulatory mechanism currently used to take ravens. Depredation permits are used to manage local problems and are not meant to be used for long-term population management.

Depredation Order

A depredation order is a regulatory mechanism that allows individuals to take birds listed under specific regulations without a permit. The Service creates depredation orders to address specific, repeated depredation or human health issues, thus reducing regulatory burden for the affected public and for the Service. Specific depredation orders exist for a variety of species and special circumstances (see 50 CFR 21.150 through 21.165), and each depredation order describes a number of requirements under which the public may exercise authority under the order, including nonlethal methods that should be employed first, methods of take allowed, and annual reporting. Currently there is no depredation order for ravens.

Control Order

The Service may develop control orders for native species protected under the MBTA which were introduced to and/or now occur outside of their normal range, and are causing depredation, property damage, or human health issues in that new range (see 50 CFR 21.168 through 21.177). This does not apply to ravens; they are expanding their range of their own accord.

Conservation Order

The Service may develop conservation orders for management of certain wildlife populations "... when traditional management programs are unsuccessful in preventing overabundance of the population." Currently the Service has developed one conservation order for birds, 50 CFR 21.60, for the control of 'light geese' (snow goose (*Chen caerulescens*) and Ross's goose (*Chen rossii*). The taking of light geese under this conservation order is based on population levels of geese by Flyway, ecological damage on their breeding grounds in Canada, and steps that Canada is taking to reduce populations.

Hunting Regulation

Certain species protected under MBTA are game species and huntable by regulations developed in cooperation with states with the structure of the four [administrative flyways](https://www.fws.gov/partner/migratory-bird-program-administrative-flyways) (see https://www.fws.gov/partner/migratory-bird-program-administrative-flyways). Ravens are not a game species as defined by the four international treaties underpinning the MBTA, neither by the MBTA or its implementing regulations, nor by any state.

Removal from MBTA Protection

Were ravens removed from coverage under the MBTA, they could be taken by anyone, at any time, by any means, in accordance with state, tribal, and local laws. However, to remove any species from the protection of the MBTA would require the negotiation with at least one of the signatories of the 4 international conventions (Canada, Japan, Mexico, or Russia) to protect migratory birds. If agreed upon, the treaties that include ravens would require amendments. This action would be undertaken by the Department of State and require concurrence from the other country for which the treaty was established.

Potential Take Levels – Modeling Raven Populations

The Service is developing a Potential Take Limit (PTL) model to evaluate allowable take of ravens (Runge et al. 2009). The PTL model allows the Service to integrate biological and policy elements into the decision-making process of authorizing the take of ravens without threatening the viability of ravens across their range. The PTL model estimates the maximum allowable annual take of ravens given management objectives and desired population size. The maximum allowable take is not a simply prescribed take level for ravens but is the predicted maximum allowable annual take that corresponds with a biologically sustainable level of annual take based on knowledge of raven population dynamics. Two recent environmental assessments (USDA 2020 and USFWS 2021) use PTL models to evaluate the effects of take on raven populations within defined geographies.

A Five Step and Three-tiered Management Approach to Targeted, Comprehensive Management

While the body of research on raven ecology has grown in recent decades, examples of science-based frameworks for managing raven populations are lacking in the published literature. This example framework employs five steps to assessing raven densities in specific geographies, and three broad tiers of management actions, including reducing anthropogenic subsidies, prey species habitat improvements, and lethal actions (Dettenmaier et al. 2021). The application of and synergistic engagement among management tiers establishes congruency between short- and long-term management actions. This design ensures that overall management actions provide immediate reductions in the impacts that high raven densities exhibit on sensitive species while simultaneously increasing the likelihood of long-term management efficacy. The example below outlines the five steps that comprise this science-driven targeted management framework, including; (1) identifying areas of highest predicted effectiveness; (2) assessing raven densities at the local scale; (3) comparing raven density estimates to established ecological threshold; (4) prescribing management actions using 3-tiered process; and (5) monitoring effectiveness of management actions and adjusting actions based on responses in raven density (Figure 4).

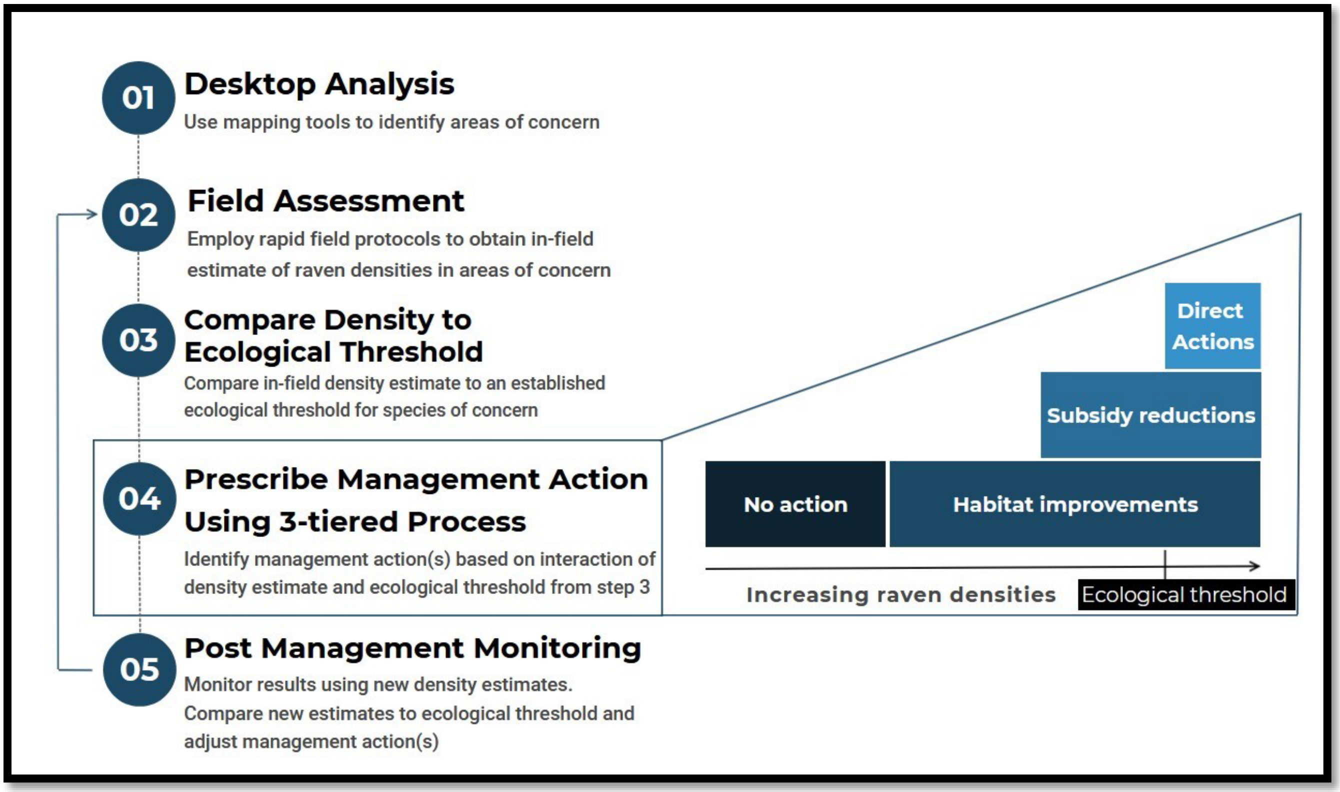

Figure 4: Diagram highlighting the three-tiered management approach to targeted, comprehensive management (Dettenmaier et al. 2021).

Step 1. Identifying Areas for Site Assessment

A geospatial desktop analysis can be conducted to identify areas at relatively coarse spatial scales to identify areas of highest priority that will then be used as candidate sites for finer-scale assessments in step 2. Spatial layers with numbers of raven density estimates, or modeled predictions can be overlaid with sensitive species distribution models to enable users to identify multiple areas where management actions are likely to be effective at reducing predation impacts on sensitive species. For example, managers could first identify areas of predicted increased raven occurrence and density. Broad-scale mapping tools for estimating raven densities have been developed across southwestern North America (O'Neil et al. 2018, Coates et al. 2020*a*). Because ravens generally impact sensitive species through the depredation of nests or juveniles (Boarman 2003, Coates et al. 2008), managers might benefit from focusing efforts on areas where high raven densities coincide with nesting or juvenile habitats for the species of concern. To achieve this, maps of raven densities are overlapped with maps of prey species breeding habitat to identify these areas at greatest risk. After these coarse-scale high-priority areas have been identified, more accurate raven densities can be estimated at the local scale.

Step 2. Employ Standardized Rapid Field Survey Protocols to Assess Local Raven Densities

A more accurate assessment of the potential risk of ravens to a prey species can be obtained through in-field estimates of local raven densities. Typically, these estimates are derived through distance sampling and incorporate estimations of detection probabilities (Buckland et al. 2015), which require substantial sample sizes. However, facing resource limitations, managers may leverage innovative methods such as the rapid assessment tool (Brussee et al. 2021). This novel method provides similar results to distance sampling, including confidence around density estimates. However, for distance sampling a very large number of surveys may be required to inform the associated detection function. The rapid assessment tool has the specific advantage of being able to reliably estimate raven density with as few as 50-100 surveys thereby reducing the sampling effort required.

Step 3. Compare Field Density Estimates to an Ecological Threshold

Negative impacts for prey species may occur at different raven densities. For example, impacts on nesting greater sage-grouse were documented when raven densities exceeded 0.40 per km^2 (Coates et al. 2020a; Figure 5) and for juvenile desert tortoise at 0.89 per km^2 when a raven nest territory was within 1.72 km (Holcomb et al. 2021). In Figure 5, the ecological threshold is represented as 0.40 ravens per km^2. This ecological threshold represents the site-level raven density at which ravens cause detectable impacts to greater sage-grouse (*Centrocercus urophasianus*). Tiers 1, 2, and 3 (see Figure 4) correspond to habitat improvement, anthropogenic resource subsidy reductions, and direct action, respectively (Dettenmaier et al. 2021).

The observed densities of ravens represent potential ecological thresholds that managers can use to guide management actions within a tiered framework. These thresholds are specific to each prey species and should be estimated using the best available science. Potential management actions can then be identified based on the interaction of the local raven density estimates and the established ecological threshold. For example, raven density estimates, along with associated upper 95% CIs, may interact with the viable species conflict threshold in one of four ways: 1) both the point estimate and upper 95% CI fall below the threshold (no action), 2) the point estimate is below but the upper 95% CI overlap the threshold (tier 1 actions), 3) the point estimate exceeds the threshold but the upper 95% CI overlap the threshold (tier 2 actions), or 4) both the point estimate and upper 95% CI exceed the threshold (tier 3 actions).

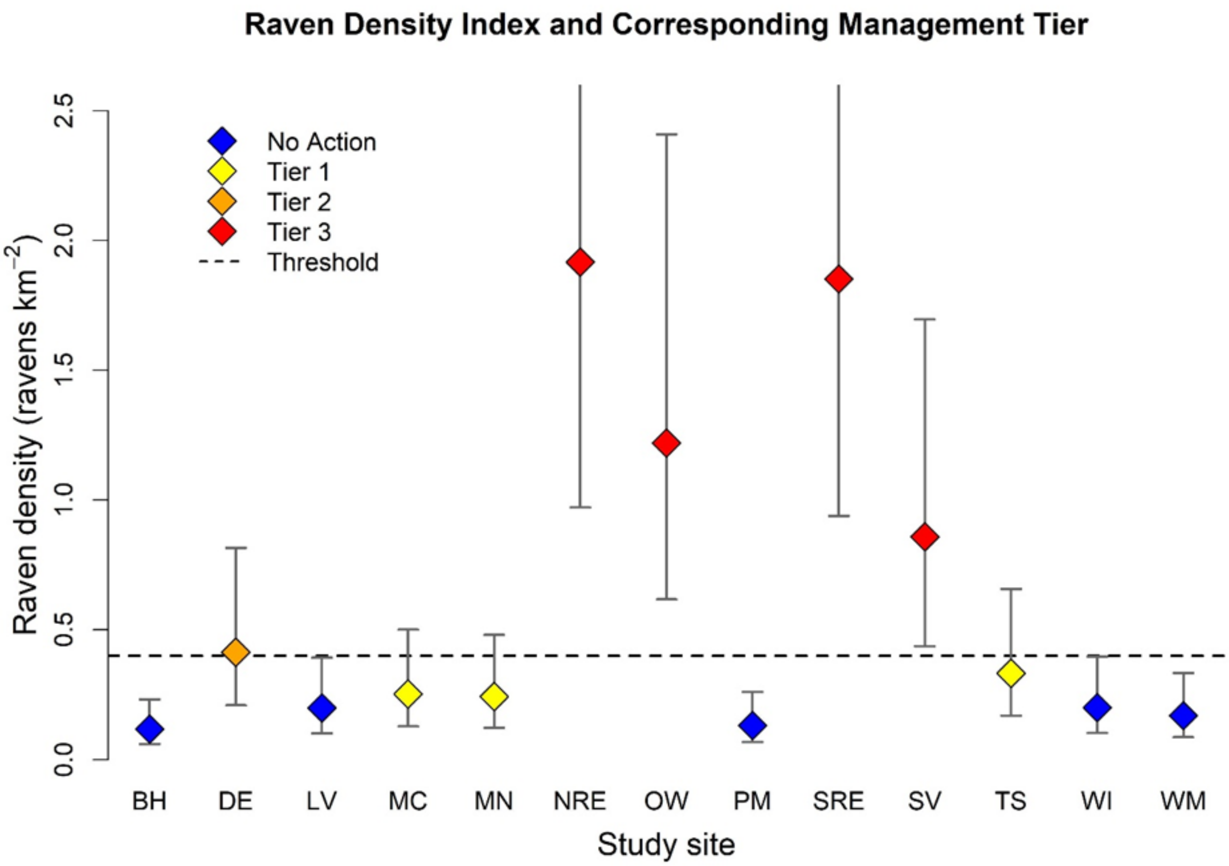

Figure 5. Identification of management action tier using the interaction of site-level common raven (Corvus corax) density estimate with the ecological threshold. BH = Bodie Hills, California; DE = Desatoya Mountains, Nevada; LV = Long Valley, California; MC = McGinness Hills, Nevada; MN =Monitor Valley, Nevada; NRE = North Reese Valley, Nevada; OW = Owyhee, Idaho; PM = Parker Meadows, California; SRE = South Reese Valley, Nevada; SV = Susanville, California; TS = Tuscarora, Nevada; WI = Winecup-Gamble, Nevada; and WM = White Mountains, California, USA.

These interactions may guide management differently across established tiers and direct management actions as described in step 4.

Step 4. Prescribe Management Actions within the 3-Tiered Process

The example framework engages three tiers of management: (1) improvements to prey species habitat to reduce the probability of nest depredation by ravens, (2) reductions in access for ravens to anthropogenic resource subsidies that provide alternative food sources (e.g., roadkill, landfills) and perching and nesting substrates (e.g., power lines), and (3) lethal removal in areas of highest risk and where low reproductive status threatens sensitive prey populations to achieve short-term goals. An essential feature of this approach is how each of the tiers are meant to build upon, and be used in concert with, any lower tiers. For example, tier 2 (subsidy reductions) actions are designed to be carried out in concert with tier 1 (habitat improvements). Further, sites targeted for tier 3 (lethal) actions would also include management actions, as identified and appropriate, that address any potential subsidy (tier 2) and habitat (tier 1) issues.

Tier 1 Management – Tier 1 targets improvements in prey species habitat quality. Predation is the proximate cause of local declines in many species' populations, with habitat quality being the underlying distal cause (Silvy 1999). For example, game bird populations that are provided adequate amounts of suitable quality habitat proliferate despite the impacts of endemic predators (Bergerud 1988). However, habitat requirements vary between species and managers will need to design habitat improvement efforts accordingly. For example, piping plover nest success is known to increase when located in territories characterized by clumped vegetation within larger areas of interspace (Gaines and Ryan 1988). For plovers, managers may choose to target habitat improvement strategies that emulate a similar vegetation heterogeneity. In the case of the Mojave Desert tortoise, restoration and augmentation of native perennial shrubs ameliorate protective cover, likely reducing the effects of predation by ravens (Abella and Berry 2016).

Tier 2 Management – Tier 2 focuses on reducing resource subsidies thereby removing the opportunity for inflated raven populations. Anthropogenic subsidies provide raven populations with resources that contribute to increases in density above the habitat's natural capacity (Marzluff and Neatherlin 2006, Kristan and Boarman 2007, O'Neil et al. 2018). Subsidies are typically alternative food resources (e.g., roadkill, landfills, livestock water troughs) or perching and nesting substrates (infrastructure such as power lines, buildings, and communication towers). In areas where subsidies are prevalent and accessible, raven populations can increase to the point of becoming decoupled from natural carrying capacity (Restani et al. 2001, Peebles and Conover 2017). Anthropogenic subsidies can also influence raven distribution and demography (Peebles and Conover 2017) and are the greatest driving factor in the increase and expansion of raven populations (Kristan and Boarman 2007). Reducing access to anthropogenic resources is a primary concern for a comprehensive raven management plan (Boarman 2003). By addressing these resource subsidies in areas where ravens are a concern (i.e., engaging Tier 2), management addresses the inflated carrying capacity of these raven populations.

Perching or nesting substrates are sometimes provided by anthropogenic infrastructure and contribute to raven population growth (Peebles and Conover 2017). Installing perch deterrents on structures like transmission lines, communication towers, and other vertical infrastructure is one strategy available for managers to reduce the use of vertical infrastructure by ravens. However, the efficacy of these devices has been mixed

(Lammers and Collopy 2007, Slater and Smith 2010, Restani and Lueck 2020) with only a handful of studies reporting effective reductions in perching or nesting on vertical infrastructure at localized scales (Liebezeit and George 2002). Dismantling or removing defunct infrastructure and repairing or replacing perch/nest deterrent structures on active infrastructure are other important strategies to reduce the prevalence of anthropogenic perching/nesting substrate for ravens (Braun 1998, Dwyer et al. 2015). Importantly, several studies have suggested that reducing anthropogenic subsidies for ravens may be most effective when actions are carried out during late winter and spring when ravens are nesting (Boarman 2003, Shields et al. 2019).

Tier 3 Management – At sites where raven impacts are directly limiting recovery of sensitive species populations, or resource managers otherwise deem necessary for achieving management objectives, direct actions (i.e., lethal removal) may be necessary to mitigate predator-prey conflicts that eliminate or substantially limit a prey species ability to maintain stable populations within conservation areas as well as corridors. Removal techniques can target breeding and non-breeding adult ravens or unhatched eggs. Strategies that target the unhatched eggs in raven nests include various methods of egg addling (hyperthermia, hypothermia, and suffocation) frequently achieved through egg oiling (Sanchez et al. 2021, Shields et al. 2019) and, to a lesser extent, the removal of active nests (Sanchez et al. 2021).

Step 5. Monitor Management Effectiveness and Adjust Based on Raven Density Responses

The final step of the management approach involves monitoring post-treatment raven densities to determine the effectiveness of the management actions. Analogous to an adaptive management framework, raven density estimates can be obtained at treatment sites and reassessed relative to the prey species viable species conflict threshold. Management actions could then be adjusted accordingly. Management could move amongst tiers, such as moving from a simultaneous engagement of tier 1 and 2 actions to employing just tier 1 actions or graduating out low-risk sites and identifying new sites for management actions.

Monitoring

Monitoring populations of ravens across multiple spatial scales is a critical element of a comprehensive management strategy. Detection of changes in population trends at the landscape and larger scales requires monitoring efforts at commensurately broad spatial scales. Without the ability to detect overall trends at broad scales and the reversal of current trends, rapid field assessment cannot determine the achievement of proposed management objectives. For this, a base of initial monitoring needs to be established. Fortunately, broad-scale monitoring data of avian species, including ravens, has been consistently collected through the BBS, an international cooperative effort between the U.S. Geological Survey and Canadian Wildlife Service. Established in the late 1960s, the BBS spans more than 50 years and represents the most extensive continuous dataset available on the status and trend of avian species in North America. Currently, the BBS consists of more than 4,800 40-km routes across the continental U.S. and Canada. Because management actions such as depredation orders occur at broad spatial scales, the BBS data lends itself well to detecting changes in trends related to actions occurring at these relatively large scales. Additionally, BBS data are collected annually, freely available, and currently being used to develop novel tools that promise to provide easily accessible trend analysis data to managers.

While monitoring at broad spatial scales is essential for providing much-needed population trend data across regions, more local-scale density estimates are still required to inform science-driven management approaches like the three-tiered approach. Monitoring efforts using point counts before, during, and after management actions provides managers the ability to assess the effectiveness of those actions and modify management accordingly. Estimation of density typically relies on detection probabilities, not easily derived from BBS data. However, point counts at the local-scale can be an efficient and effective method to obtain local estimates of density needed to inform a three-tiered approach. Examples of methods for local-scale estimation of raven densities point counts include Raptor, Raven, Horse, and Livestock (RRHL) surveys (Coates et al. 2020*a*). These protocols are supported in the peer-reviewed literature, produce high-resolution density estimates with relatively low sampling effort, and be easily integrated into new monitoring frameworks.

Communication

As stated in the Charter, the goal of this framework is to provide guidance that leads to consistent approaches to raven management across spatial and administrative boundaries. Engagement with and transparency for all relevant stakeholders and sovereigns (tribes and states) are required.

Partner and Stakeholder Engagement

Successful use of the Species Conflict Framework is reliant on engaging the appropriate partners to be on the Core Team and to assist with each step of the framework as well as effectively engaging and communicating with stakeholders and sovereigns.

Federal

Federal partners on the Core Team include representatives from the U.S. Geological Survey, APHIS WS, Department of Defense, and Bureau of Land Management. The team members from these partner agencies participate in monthly calls and attend in-person meetings. They advise the Service Core Team members on conflicts occurring in their jurisdictions with ravens, research associated with the conflicts, past, current, and planned management activities, and provide information and updates to their organizations as needed.

State

State partners include a representative from both the Pacific and Central Flyway Non-Game Technical Committees. While also state wildlife agency staff, their role is to represent the Flyways' interests, as well as act as a liaison to their respective Flyways.

Tribes

The Service National and Associate Native American Liaisons both participate on the Core Team to ensure the interests of tribes are considered at every step of the process. The Core Team is committed to adhering to the Department of Interior's commitment to honoring tribal sovereignty and is able and willing to honor requests for consultation through the appropriate channels.

Private

Through the stakeholder engagement step of the framework, the Service made webinars and an online information collection portal available to all interested audiences, including private individuals, organizations, and industries (discussed more below). The Service highly values the public's input, perspectives, and potential to be affected by management plans resulting from this strategy.

Communication Strategy

The geographic scale and complexity of addressing raven conflicts in the U.S. requires a multi-faceted but consistent communication strategy. Below are the many mechanisms being employed by the Core Team.

Webinars

The Core Team held three webinars (2/20/2020, 3/3/2020, and 3/5/2020) for the general public, and two for tribes (2/28/2020 and 3/4/2020). The purpose was to notify participants of the goals and objectives of the Core Team and solicit input on this process through an online portal. In particular, we were requesting input on both the range of impacts or issues that ravens cause, and any concerns about raven populations or the cultural significance of ravens.

Participation in the public webinars was high. We used RSVPs to estimate attendance. Approximately 100 participates RSVP'd for each, with a total of 315. In addition, there was interest and engagement with the two tribal-only webinars. We received 15 RSVP's.

Online Site and Tools - Summary of Submissions

We reached out to stakeholders via webinars, etc. and encouraged them to provide input via an online submission tool.

We received comments from 73 independent stakeholders through this process. This included detailing specific impacts of ravens to a variety of resources, data on ravens or depredation impacts, cultural value of ravens, scientific literature, and general information. Comments were received from federal (17), state (16) and other (9) agencies, tribal governments (3), non-governmental organizations (14), counties (5), cities (2), universities (2), and industries (5) across 10 different states (AK, AZ, CA, CO, ID, NV, OR, UT, WA, and WV). This information was used in development of this technical document. The following table summarizes stakeholder input (Table 4).

Table 4: Summary of stakeholder input.

Topic		Number of comments[1]	Affiliation of commenters	Location(s) of concern	Primary concern(s)
Impacts to Wildlife	Western Snowy Plover	10	California State Parks, WA Dept. of Fish and Wildlife, East Bay Regional Park, APHIS WS, U.S. Fish and Wildlife Service, Point Blue, State of Nevada	CA, NV, OR, WA	Ravens predate on nests and chicks (some data presented); ravens alter snowy plover nest site selection; ravens may preclude snowy plover recovery; request for nonlethal control options; suggestions for control measures; literature provided
	California Least Tern	2	East Bay Regional Park, APHIS WS	CA	Ravens predate California least tern nests and chicks
	Common Murre	1	U.S. Fish and Wildlife Service	CA	Attacks on common murre colonies have been mitigated with lethal raven control
	Waterfowl	1	Utah Division of Wildlife Resources	UT	Ravens are removed from State Waterfowl Management Areas
	Greater Sage-Grouse	18	Elko County; Utah Chukar and Wildlife Foundation; Utah Division of Wildlife Resources; Washington Dept of Fish and Wildlife; Malheur Conservation District; Garfield County, UT; State	CA, ID, NV, OR, UT, WA	Summary of raven and sage-grouse literature; concerns with rising numbers of ravens; ravens predate on nest and chicks; concerns with the amount of money spent on GRSG that is negated by raven depredation; monitoring techniques for ravens; tactics for subsidy management; request for more protection of sage-grouse nests and chicks, including lethal control, and control options for private landowners; remove grazing to protect GRSG; concern that ravens are the scapegoat for habitat and hunting issues.

Topic		Number of comments[1]	Affiliation of commenters	Location(s) of concern	Primary concern(s)
			of Nevada; consulting firm; private landowner		
	Gunnison Sage-Grouse	3	Bureau of Land Management, private citizen	CO	Ravens are a limiting factor for Gunnison sage-grouse populations; Ravens eat eggs and chicks; Request for the history of the 1976 MBTA changes.
	Other upland game birds	2	Washington Dept. Fish and Wildlife	NV, WA	Ravens predate nests of sharp-tailed grouse; raven numbers are increasing
	Desert Tortoise	5	Utah Division of Wildlife Resources; Washington County, UT; State of Nevada	CA, UT, NV	Ravens predate desert tortoise hatchlings; summary of literature; plan to address subsidies; raven numbers growing
	Special status and endangered species	5	Arizona Game and Fish; Center for Natural Lands Management, NGO; consulting firm; National Park Service	AZ, CA, CO, NV	Ravens are increasing and depredating several special status species; request for increased and streamlined take or hunting season; request for a formal control order to protect listed species.
Impacts to Livestock	Cattle	6	private landowner, APHIS WS	ID, NV, OR, UT	Ravens attack calves; ravens contaminate feed; ravens cause financial losses; request to remove protections for ravens; request for nonlethal methods for raven control
	Sheep	1	Rio Blanco County Woolgrowers Assoc.	CO	Ravens kill and injure lambs and sheep
	General	8	Dolores County, CO; Garfield County, UT; private citizen; Utah Division of Wildlife Resources; State of Nevada	CO, ID, NV, UT	Ravens depredate young livestock; ravens spread disease between feedlots; ravens are an economic impact to farmers and ranchers; required compliance with grazing regulations should provide relief for dealing with raven damage; continued support for APHIS WS control efforts; monitoring is challenging due to size of landscape; ravens are a scapegoat for not addressing overgrazing by livestock

Topic		Number of comments[1]	Affiliation of commenters	Location(s) of concern	Primary concern(s)
Damage to infrastructure	Powerlines	5	Power company, electric cooperatives	AZ, NV, UT	Ravens cause damage to powerlines and associated equipment, causing power outages, and increasing potential for wildfire; addressing raven problems is costly for companies; request for opportunity to develop local solutions; request to increase take of ravens
	Buildings	2	Dugway Proving Grounds, U.S. Forest Service	UT	Ravens nest on structures; ravens cause damage to buildings
	Other	3	USACOE, Utah Division of Wildlife Resources	CA, UT, WV	Ravens cause damage to rubber expansion joints on dams; ravens have caused undefined damage to personal property; increased subsidies have increased raven numbers
Human health and safety		2	Local airport authority, Ruby Tribal Council	AK, SD	Ravens need to be hazed off regional airports to protect planes; ravens congregate at local dumps; ravens challenge dogs for food
Management suggestions		6	Quad State Local Governments Authority; Mayor of Ridgecrest, CA; Mojave Desert Resource Conservation District; Bureau of Land Management; U.S. Fish and Wildlife Service	AZ, CA, NV, UT	Raven numbers should be significantly reduced to improve management efficacy; require mandatory subsidy management (e.g., locked dumpster lids); institute a raven hunting season; remove ravens from the MBTA; establish better working relationships with local communities; research to identify cause of decline of wildlife species before implementing raven control; identify level of take that separates a categorical exclusion from a full NEPA review
Cultural significance		3	Nondalton Tribal Council, Klamath Tribes Culture and Heritage Department, Ruby Tribal Council	AK, OR	Any raven management must be sensitive to tribal concerns; ravens are sacred to many tribes

[1] The total number of comments in this column exceed the total number of responses received as many commenters discussed multiple topics.

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Appendix A - U.S. Fish and Wildlife Service Migratory Bird Program -- Raven Core Team Charter

Project Charter: Addressing Common Raven (Corvus corax) Conflicts in the Western United States & Alaska.

Migratory Bird Leadership Team Liaison: Ken Richkus, Chief, Division of Migratory Bird Management

Purpose: To develop recommendations for reducing conflicts between ravens and imperiled species conservation and/or agricultural and other operations by applying the U.S. Fish and Wildlife Service's (Service) Species Conflict Framework (framework).[1]
Federal agency members: FWS, USDA, DOD, USGS

Non-Federal members: State wildlife agencies such as NDOW, CDFW, NMDGF

Members: Eric Kershner (FWSHQ), Amedee Brickey (FWSR8), Michael Green (FWSRI), Jordan Muir (FWSR7), Brian Smith (FWSR6), Patrick Devers (FWSHQ), Jo Anna Lutmerding (FWSHQ), Pat Deibert (FWSR6), Kerry Holcomb (FWSR8), Thomas Leeman (FWSRS), DJ Monette (Scott Aikin proxy) (FWSHQ), January Johnson (FWSHQ), Peter Coates (USGS), Walter Christensen (DOD), Colin Leingang (DOD), Mike Yeary (USDA), and Joe Barnes (NDOW), Erin Duvuvuei (NMDGF), Scott Carleton (FWS-Albuquerque Regional Office).

Available as needed: Ted Swem (FWSR7), Kristin Madden (FWSR2)

Process:

The goals of this effort are in line with those of the framework's guiding principles:

- Adhere to the Service's responsibilities to the four international conventions [with Great Britain (on behalf of Canada), Mexico, Japan, and Russia] and implement the Migratory Bird Treaty Act (MBTA)
- Clearly articulate the conflict(s) and the factors (e.g., biological, anthropomorphic) contributing to the conflict(s)

[1] A Conceptual Framework for Evaluating and Responding to Conflicts with Migratory Bird Species. U.S. Fish and Wildlife Service. 2018.

- Develop a large-scale strategy for the USFWS western regions (defined below) to address and reduce conflicts with ravens that can guide local scale decisions
- Reduce the conflict(s) through non-lethal options, and if necessary, seek the minimal amount of lethal take necessary
- Provide guidance that leads to consistent approaches to raven management across spatial and administrative boundaries.
- Engage in a respectful dialogue
- Engagement with and transparency for 11 relevant stakeholders and sovereigns (Tribes, States)

Use of the framework will guide the Core Team to address raven conflicts in western legacy Service Regions Alaska (R7), Pacific (Rl), Pacific Southwest (R8), Mountain-Prairie (R6), and Southwest (R2). The Core Team will establish an appropriate stakeholder engagement process, develop, and evaluate management options, conduct a biological assessment, if necessary, implement a selected management option(s), and then evaluate management actions for effectiveness. If the conflict is found not to be resolved at an acceptable level upon evaluation, the framework will be re-engaged at the appropriate step.

The Core Team comprises Service and non-Service members who all play an essential role in gathering and contributing information and taking part in discussions for the purposes of completing the framework, such as developing a proper stakeholder process and assimilating information and feedback collected in that process. Core Team members will be responsible for determining any information that is confidential in nature and articulating that to all other Core Team members. All materials or information obtained by the Service are subject to the FOIA, and this will be clearly communicated to stakeholders when soliciting input and information.

It will solely be the responsibility of Service staff to ensure that the framework is followed properly and to completeness. Service staff will be responsible for deciding on the management actions to be implemented by the Service where it has jurisdiction and is within the bounds of existing Federal regulations, conducting necessary rulemaking to implement management actions, documenting these procedures, and developing a final management strategy for ravens in the legacy Regions 7, 1, 8, 6 and 2.

Non-Service members of the Core Team may act as advisors to the Core Team as a whole and liaisons to their respective institutions to provide and solicit information.

Product(s):

Develop a raven management strategy for the western United States.

Timeframes:

Team is chartered for two years upon signing of the charter. Charter can be extended by the MBLT as needed.

Draft raven management strategy by December 2020.

Supporting Resources - The Core Team will rely on support from and communication with the MBLT on process and the Pacific and Central Flyway nongame technical sections for coordination with states. Assistance in effectively communicating with Tribes in the steps of the framework will be requested of the Assistant Director for Migratory Birds in the form of a signed letter informing federally recognized tribes of webinars during stakeholder and sovereign engagement. Other resources include travel expenses for two in-person meetings that are necessary for the Core Team to make effective and efficient progress following the steps of the species conflict framework. An online data portal must be developed as a platform for stakeholders to submit information and this will be developed via contract with DJ Case and Associates.

Reporting Plan - The Core Team will regularly update the Pacific and Central Flyway representatives of progress to ensure proper coordination with the states. The MBLT will be briefed on progress as needed and at the conclusion of each step of the framework.

Approval: All Team charters require the signature of the Assistant Director for Migratory Birds.

Jerome Ford 10/1/19

Assistant Director for Migratory Birds Date

Suggested citation:

U.S. Fish and Wildlife Service, Division of Migratory Birds Management (2023). Management of Conflicts Associated with Common Ravens in the United States: *A Technical Review of the Issues*, 2023. U.S. Fish and Wildlife Service Migratory Bird Program Division of Bird Conservation, Permits, and Regulations Branch of Bird Conservation.

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