U.S. Fish and Wildlife Service

Final

Environmental Assessment

Scientific Collecting Permit for Common Raven Removal

Prepared by

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1 Introduction

The Oregon Department of Fish and Wildlife (ODFW) applied to the U.S. Fish and Wildlife Service (Service, we) for a scientific collecting permit (50 CFR 21.23) to conduct research on Common Ravens (*Corvus corax*, 'ravens') in Baker County, Oregon. The proposed study (Appendix A), in collaboration with Oregon State University (OSU), is to determine the effect of lowering raven density on sage-grouse populations, and to compare the effectiveness of lethal and non-lethal techniques for lowering raven density. Since 2005 the Greater Sage-grouse (*Centrocercus urophasianus*, 'sage-grouse') population in the Baker Priority Area for Conservation (Baker PAC, Figure 1) has declined by 75% (Oregon Department of Fish and Wildlife 2019; see section 5.3.1). There are many environmental factors that negatively affect sage-grouse populations, but among them, ravens in high densities are thought to limit sage-grouse reproductive success (Coates and Delehanty 2004, Bui et al. 2010, Coates and Delehanty 2010, Dinkins et al. 2016, Peebles et al. 2017; see Section 7.2).

Lethal removal of ravens requires a permit under the Migratory Bird Treaty Act. Permit issuance is a Federal action, and as such requires evaluation under the National Environmental Policy Act (NEPA)(42 U.S.C 4321 et seq.). This Final Environmental Assessment (Final EA) evaluates reasonably foreseeable environmental impacts resulting from issuance of a permit and may serve as the NEPA documentation for its issuance. We are considering four alternatives, described in detail in Section 8, and summarized here.

Alternative 1 – Deny the permit. Under this alternative, we would not issue a scientific collecting permit for either administrative reasons or because the proposed activity may potentially threaten a wildlife or plant population, including ravens.

Alternative 2 – Issue a permit for take of nests only (eggs only). Under this alternative the Service would issue the scientific collecting permit authorizing the take of nests only. This authorization would allow up to 100 nests to be removed per year, for three years. Nest take would be limited to inactive or active nests with eggs and would not include the take of nests with nestlings.

Alternative 3 – Issue a permit for take of raven nests and adults as requested by ODFW (Preferred Alternative). Under this alternative the Service would issue a scientific collecting permit authorizing take of up to 100 raven nests per year for three years (300 nests total), and the take of up to 400 adult ravens per year for two years (800 adult ravens, total). Nest take would be the method used in the initial year of the study for up to three years, depending on the response of sage-grouse and ravens. If nest take is determined to be ineffective, then a corvid-specific avicide, DRC-1339, would be applied either by ODFW or their licensed agents to take adult ravens. The intent of adult take would be to remove only as many adult ravens as would be necessary to achieve the target density of 0.15 ravens/km^2, leaving about 200 adults in the Baker PAC.

Alternative 4 – Issue a permit for adult take only. Under this alternative, the Service would authorize the take of up to 400 adult ravens per year for up to three years beginning in the first year of study; 1,200 adults could potentially be taken under this alternative. As under the adult take scenario in Alternative 3, the intent would be to remove only as many adult ravens as would be necessary to achieve the target density of 0.15 ravens/km^2, leaving about 200 adults in the Baker PAC.

2 Need for Action

The Service received an application from ODFW for a scientific collecting permit on April 11, 2018. We evaluated that application in a Draft EA published February 19, 2020, and subsequently the applicant revised their application on November 9, 2020. Comments received on the initial draft resulted in substantial changes to ODFW's study proposal (see Section 4. Scoping), which in turn was consequential enough to require a new assessment. A new Draft EA corresponding to the applicant's revised application was published January 8, 2021. Substantial comments received on the January 2021 draft have been incorporated into this Final EA.

Upon receipt of a properly executed application for a permit, the Service is required to make a decision and issue the appropriate permit unless one of the criteria under Issuance of Permits applies (see Section 3). The Service's purposes are to ensure that its permit decision is consistent with the Migratory Bird Treaty Act (MBTA; 16 U.S.C. §703-712), its underlying treaties, and implementing regulations, and that it complies with all other applicable Federal laws and regulations. The MBTA gives the Service broad authority to protect birds, but also to regulate their taking as long as their conservation is assured; the issuance of this permit must ensure that authorized take will not potentially threaten ravens or other wildlife or plant populations (50 CFR 13.21(b)(4)).

3 Decision to be Made

A scientific collecting permit is required before any person may take, transport, or possess migratory birds, their parts, nests, or eggs for scientific research or educational purposes. This Final EA evaluates four alternatives (see Section 8) regarding issuance of such a permit to authorize the take of ravens in Baker County, OR. To issue a scientific collecting permit, we must determine whether or not the application is complete (as defined in 50 CFR 13.12) and the activity meets the general permit issuance criteria and requirements (50 CFR 13.21), as well as the specific requirements for a scientific collecting permit (50 CFR 21.23). Under federal regulation, upon receipt of a complete permit application, the Service must issue the permit unless the issuance criteria are not met or one or more of several disqualifying factors apply. These will be specifically addressed in a final decision.

4 Scoping

We published the first Draft EA on February 19, 2019 for a 30-day public comment. Prior to publication of the February 2019 Draft EA, we invited comment from tribes in the vicinity of the proposed action, the Nez Perce and Burns Paiute. Members of the Confederated Tribes of the Umatilla Indian Reservation were consulted earlier during ODFW's development of their study plan, for their opinions on raven and sage-grouse population management activities. ODFW also consulted other conservation stakeholders, including the Portland Audubon Society, Oregon Natural Desert Association, and Oregon Wild regarding the proposed action prior to publication.

We received 1,455 form letter responses and 41 unique responses during that public comment period. Thirty-five were against the action, five were in favor of it, and one was of no stated opinion. Our responses to those comments were summarized in the second draft EA, published January 8, 2021 and are available upon request.

Some public comments on the February 2019 Draft EA prompted ODFW to change their study proposal and thus submit a revised application for a scientific collecting permit. ODFW's original (2018) study plan proposed three years of adult raven take (≤500 ravens/year); this was revised to implement an adaptive management approach and initiate raven management with raven nest removal during the first year of study and proceed to adult take only if nest removal alone does not confer benefits to sage-grouse. Several commenters also suggested that take of adults should not occur while nestlings are in the nest, thereby avoiding the starving of nestlings because one or more adults at that nest were killed. In response, ODFW modified the season of proposed nest and adult raven take activities to avoid harm to nestling ravens. ODFW also expanded the description and analysis of the non-lethal activities which will be carried out in the Cow Lakes PAC in response to public comment. Other comments focused on the design of and merits of the study. A summary of these and other substantive comments, and our responses to them, are in Appendix C.

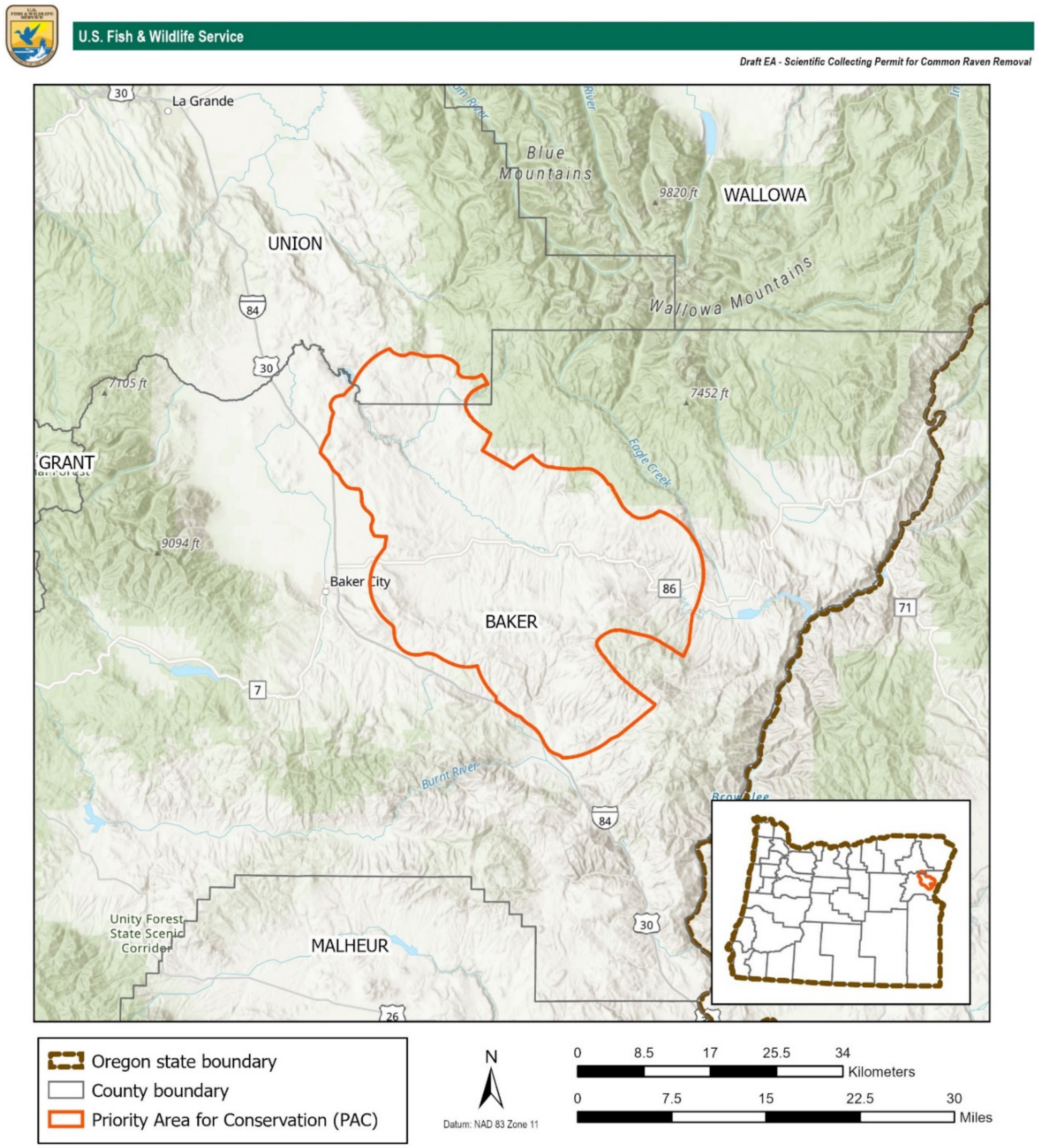
We analyzed the effects to the environment under ODFW's revised application (dated November 9, 2020) in a second Draft EA published on January 8, 2021 for a 30-day public comment period. We received 132 letters in response to this second draft. Letters expressed both support for and disapproval of the proposed action alternative. See Appendix C (Table C-1) for a summary of public comments and our responses. Two comments on this second plan prompted additional changes by ODFW to the study; instead of one year of nest take, ODFW proposes two years of raven nest take before evaluating its efficacy for improving sage-grouse productivity. In addition, ODFW and the Service have engaged in further discussions with the Bureau of Land Management (BLM) regarding compliance with BLM land use plans, as both the Baker and Cow Lakes PACs overlay BLM lands.

Our analyses of effects in both Draft EAs, as in this Final EA, focused on effects to raven populations, sage-grouse, non-target species of birds, as well as to members of the public and to members of tribes who might be affected by the Service permitting the take of ravens.

5 ODFW's Proposed Study

This study would be the action authorized under Alternative 3 (see Section 8.5).

Scientific evidence suggests that ravens in high densities, such as occur in Baker County, have a disproportionately large, negative effect on sage-grouse nesting success (see Section 7.2). This study (described in depth in Appendix A) would further examine this effect. ODFW proposes to use lethal and non-lethal techniques to reduce raven densities in the vicinity of nesting sage-grouse, and study the effect on sage-grouse nest success. The study is occurring in the context of a large, targeted restoration effort to enhance and restore sage-grouse habitat with the goal of reversing local sage-grouse declines (see Section 7.3).



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Basemap: World Topographical Map
Source Data: OR_Counties.shp, Named_Core_15Jan2014_UTMZ11.shp, or_state_boundary_dissolve.shp
File: C:\Users\jcupples\Documents\ArcGIS\Projects\Raven

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Figure 1. Baker County, Oregon and Baker Sage-grouse Priority Area for Conservation (PAC).

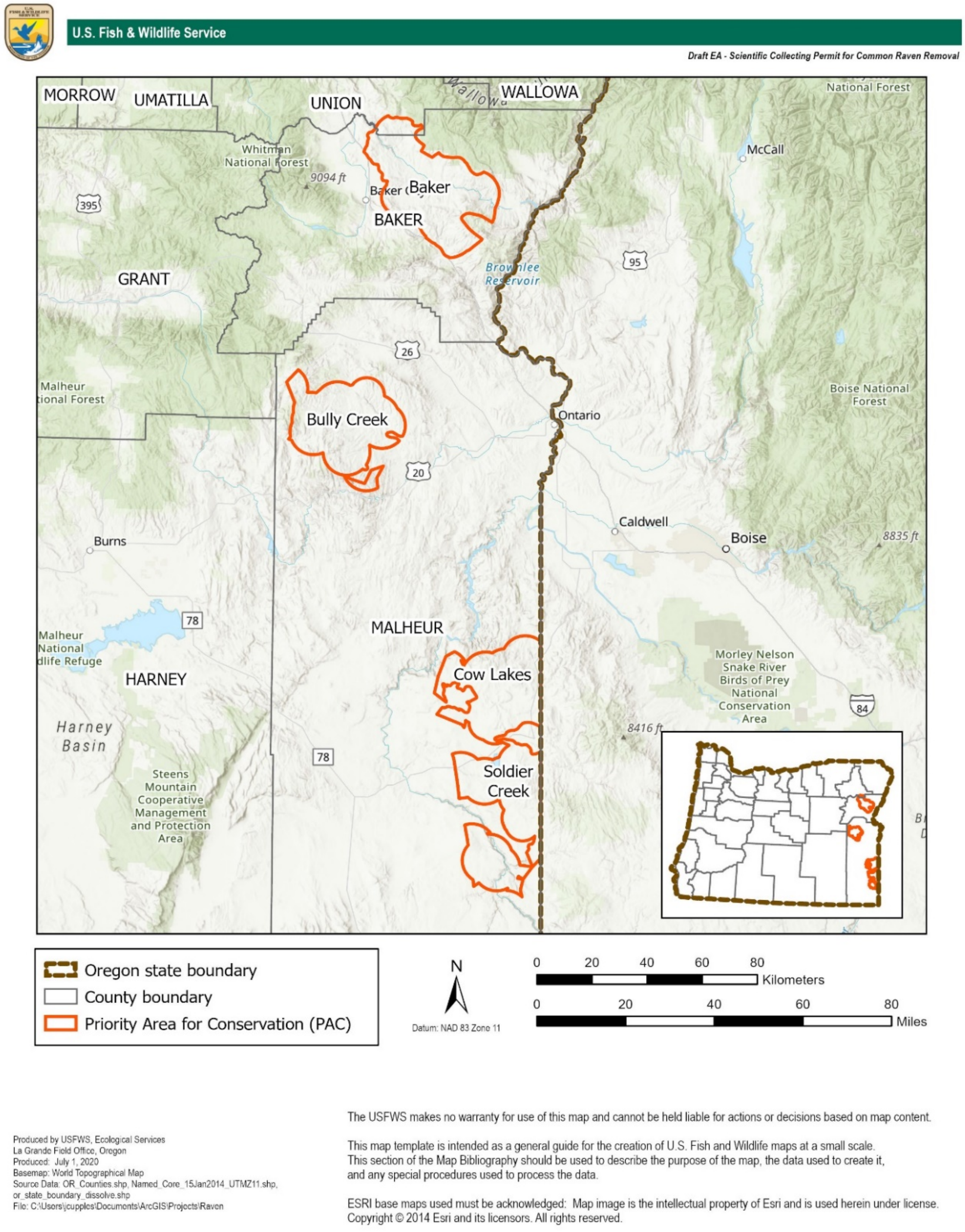

Figure 2. All study areas in ODFW/OSU's before-after experimental design, including four Priority Areas for Conservation (PACs).

The study would occur across three study areas that encompass four PACs (Figure 2). Lethal removal of ravens would occur in one area (Baker PAC), non-lethal raven reductions would occur in another area (Cow Lakes PAC), and no raven reduction techniques would occur in the Bully Creek and Soldier Creek PACs (also termed the 'control' area). Collection of pre-treatment data (prior to lethal and non-lethal raven population manipulation) was initiated in March 2017. Since then, 163 sage-grouse hens across four study sites were fitted with VHF and GPS transmitters (Baker n=43; Bully Creek n=58; Cow Lakes n=25; Soldier Creek n=37), allowing researchers to collect nesting and brood activity prior to, during, and after raven treatments (lethal and non-lethal). Sage-grouse will continue to be outfitted with transmitters and tracked throughout the course of the study in order to compare pre-treatment data with post-treatment data to assess the effectiveness of both lethal and non-lethal raven management. This study therefore follows a BACI (before-after-control-impact) design where results can be compared across pre-treatment, treatment, and control sites (Appendix A).

5.1 Adaptive Framework Scenarios

The study would occur for up to four years, and incorporates nest removal and potentially also adult take in the Baker PAC using an adaptive decision framework conforming to two potential scenarios (Figure 3). Under both scenarios, ODFW proposes to remove up to 100 raven nests each year for the first two years. In scenario 1, if nest removal improves sage-grouse nest success (compared to non-treatment areas) and results in decreased raven occupancy, ODFW would remove up to 100 raven nests in the third year (without taking adult ravens; maximum take of 300 nests over a total of three years). In scenario 2,

Year 1		Year 2		Year 3		Year 4
Nest Take [n = 100]	→	**Nest Take [n = 100]** Raven occupancy decreases and sage-grouse nest success increases = **Successful**	→	**Nest Take [n = 100]**		**NA**
Nest Take [n = 100]	→	**Nest Take [n = 100]** Raven occupancy remains stable or increases and sage-grouse nest success does not increase = **Ineffective or Inconclusive**	→	**Adult Take [n = 400]**	→	**Adult Take [n = 400]**

Figure 3. Adaptive take scenarios proposed in the study.

if nest removal after two years is either inconclusive or ineffective (for example raven occupancy remains unchanged or increases compared to treatment areas, and sage-grouse nest success does not increase), then ODFW proposes to lethally remove up to 400 ravens annually for 2 years to achieve a lower raven density in the Baker PAC (maximum take of 200 nests and 800 adults over a total of four years).

The primary intention of nest removal is to change the foraging behavior of territorial, nesting ravens. Studies have shown that breeding ravens forage intensively in small territories and utilize natural food sources, while non-breeding ravens range farther and are more likely to make use of single point food sources associated with human presence (e.g. dumps; Webb et al. 2012, Harju et al. 2018). However, when raven nests fail (either naturally or through nest destruction), breeding ravens may adopt the wide-ranging foraging strategies of non-breeders and thus may depredate native prey less (HWA Wildlife Consulting 2017, Harju et al. 2018). Dispersed foraging behavior by ravens may relieve depredation pressure on sage-grouse (HWA Wildlife Consulting 2017) in the Baker PAC. Over time, reduced raven nest success may also temporarily lower the local raven density in the Baker PAC.

ODFW anticipates removing a maximum of 300 nests (≤100 nests per year) over the course of the study, if nest removal proves to effectively reduce raven occupancy and increase sage-grouse nest success. It is estimated that there could be 37 to 268 raven territories in the Baker PAC (Section 6.1). Whether or not ODFW will need to remove 100 nests annually after the initial year will depend on the extent to which some ravens re-nest or emigrate.

The intention of removing adult ravens, if that method were to be implemented, is to directly and quickly reduce raven densities in the Baker PAC. Several researchers have independently demonstrated that high raven densities above 0.20 – 0.40 ravens/km^2 negatively affect sage-grouse nest success, recruitment, and population trend (Bui et al. 2010, Coates and Delehanty 2010, Dinkins et al. 2016, Peebles et al. 2017). When raven density was reduced to about 0.20 ravens/km^2 sage-grouse nest success and lek attendance increased over time (Dinkins et al. 2016, Peebles et al. 2017). In this study, if adult take is implemented, ODFW would attempt to reduce the current density from approximately 0.44 ravens/km^2 to about 0.15 ravens/km^2.

Under the scenarios involving adult take ODFW would remove up to 400 ravens per year for two years for a maximum take of 800 ravens (Figure 3). Since the estimated population of ravens is about 600 birds, take during the second year would likely be substantially fewer than 400, depending on immigration and productivity and the number of ravens needed to maintain a density of about 0.15 ravens/km^2. ODFW would monitor ravens across the Baker PAC and adjust take levels to achieve that target density.

During this same time period, non-lethal techniques to reduce raven densities will be used in the Cow Lakes PAC (Figure 2). These techniques include removal of raven food subsidies like road-kill on highways and livestock carcasses in rangeland, and strategies to deter raven nesting and perching (Appendix A).

5.2 Raven Management Methods

ODFW proposes two techniques to reduce the impacts of ravens on sage-grouse nesting success in the Baker PAC: removal of nests used by breeding ravens and lethal removal of adults. If nest removal is determined to be unsuccessful under scenario two of the proposed study, the raven management method will shift to the take of adult ravens using the toxicant DRC-1339. Non-lethal techniques to lower raven densities will be used to reduce raven densities in the Cow Lakes PAC; non-lethal strategies may include removal of raven attractants such as road-killed animals and livestock carcass dump sites, as well as modifying aspects of the human-built environment that might invite raven nesting or perching. And finally, no raven treatment will occur in a control site encompassing the Bully Creek and Soldier Creek PACs.

5.2.1 Nest Removal

Raven nests will only be manipulated within 2 km of sage-grouse nesting habitat. ODFW proposes to manually destroy nests and humanely euthanize raven eggs. Nest removal will occur from 1 January until 10 April, annually, for up to three years. The ending date of 10 April corresponds to 10 days prior the first observed raven nestling within the OSU study, 20 April. Raven nests will be taken prior to hatch to avoid killing hatchlings in the nests. ODFW proposes to remove nest material and eggs first; egg-oiling is only proposed as a technique of last resort if a particular pair of ravens attempt a third re-nest following two prior nest removal efforts.

If egg-oiling is used, ODFW would use methods described by (USDA-APHIS 2001b). The method involves coating eggs in the nest with 100% food-grade corn oil, using a pressurized backpack or hand-held sprayer. USDA's Animal and Plant Health Inspection Service (APHIS) directs applicators to spray eggs at least five days after the laying of the last egg in a clutch and at least 5 days before hatching. This method prevents air exchange through the eggshell and ultimately prevents hatching. Because egg-oiling does not destroy the eggs, nesting birds generally continue to incubate beyond the expected hatching date, thereby reducing or preventing re-nesting efforts. Nests treated with oil would be monitored to determine status and ultimate nest success.

Nest removal activities on BLM lands will not occur two hours before sunset to two hours after sunrise from March 1 through June 30 within 1.0 mile of occupied leks. Nest removal will not require off road vehicle use, and all nest removal would be done by hand. No methods will be used that might disrupt sage-grouse nests nearby, for example using loud machinery or chainsaws.

5.2.2 DRC-1339

A common method by which ravens are taken to reduce damage to livestock operations or depredations on species of concern, is through the use of the avicide, DRC-1339. Stations baited with chicken eggs will be used to attract ravens, and then DRC-1339 would be injected into the eggs which would then be consumed by the ravens; this method was used successfully by APHIS' Wildlife Services program, in

Nevada and Wyoming to reduce raven densities and improve nest success of sage-grouse (Coates and Delehanty 2004, Dinkins et al. 2016).

DRC-1339 (3-chloro-p-toluidine hydrochloride) is registered with the Environmental Protection Agency (EPA Reg. No 56228-29) to control crows, ravens, and magpies (Family Corvidae – 'corvids') (Environmental Protection Agency 2016). DRC-1339 is most often injected into chicken eggs which are placed at bait stations selected for their likely exposure to depredating ravens. DRC-1339 is the avicide of choice because of its relatively high toxicity to corvids, low-to-moderate toxicity to most raptors and other avian species, and almost no toxicity to mammals (DeCino et al. 1966, Schafer Jr 1981, Eisemann et al. 2003). While DRC-1339 is toxic to most songbirds, pigeons and doves, and corvids, it is considered highly selective because (1) the delivery method can be targeted to avian species that consume eggs (e.g. land-based predacious species such as ravens, not seed-eating, insectivorous, or other kinds of birds); and (2) the lethal dose for corvids is ≤10 times that of raptors and mammals (Ford 1967, Sterner et al. 1992). Numerous studies show that DRC-1339 poses minimal risk of primary and secondary poisoning to most non-target and threatened or endangered species (DeCino et al. 1966, Cunningham et al. 1979, U.S. Department of Agriculture 1997, Eisemann et al. 2003). Non-targets that might be at risk are other corvids, i.e. black-billed magpie and American crow; measures to reduce the likelihood of non-target exposure are discussed below (Section 5.2.2.2), and the effects of taking non-target species are discussed in the analyses of the alternatives (Section 8).

Bentz et al. (2007) reported that DRC-1339 is considered non-hazardous to predators or scavengers because the chemical is metabolized and its non-toxic metabolites are excreted by the target animal within a few hours after ingesting the treated bait. DRC-1339 also degrades rapidly when exposed to moisture, sunlight, heat, or ultraviolet radiation (Tawara et al. 1996). Bentz et al. (2007) reported that DRC-1339 is environmentally safe in that it binds tightly to soils, has low mobility, degrades rapidly and will not migrate.

The useful life of DRC-1339 can vary between a couple of hours when under high humidity and sunlight to more than a week under dark, dry conditions (Bentz et al. 2007). The half-life of DRC-1339 in biologically active soil is about 25 hours, and identified metabolites have low toxicity. Because DRC-1339 degrades rapidly in soils, does not persist, and binds tightly to soils, it is unlikely that DRC-1339 is translocated into plants (USDA-APHIS 2001a).

5.2.2.1 Bait Placement

The label for this registered pesticide requires the applicator to observe the baiting site for evidence of non-target activity before placement of treated egg baits, and implement several other safeguards that prevent non-target exposure (Environmental Protection Agency 2016). ODFW or their agents plan to place untreated hard boiled chicken eggs at potential bait sites and monitor them using camera traps. If non-target species are observed at the potential treatment site or consuming eggs, or if no ravens are observed at these pre-bait sites, the location will not be used during actual baiting. The DRC-1339 label requires that applicators observe the bait site (recommended to be from a distance) to determine if non-target species are attracted to the bait sites or if ravens are potentially caching eggs that non-target corvids might pilfer. If non-target species (e.g. other corvids) are observed and/or the applicator determines that non-target exposure is likely, the site will be excluded from future baiting. Bait sites that are not visited by ravens will be cleared of treated eggs and no longer used. This approach will help reduce the potential of ravens caching eggs that other corvids might eat. At sites where ravens congregate, only 1 to 4 eggs will be placed at a maximum of every 7 days. If eggs remain after 7 days then they will be removed, disposed of, and that baiting site will most likely not be used again that year. If caching is suspected, then only 1 to 2 treated eggs will be placed at each bait site to reduce the possibility of caching.

Removal will occur from 1 January until 10 April, annually. The ending date of 10 April corresponds to 10 days prior the first observed raven nestling within the OSU study, 20 April. Should nestlings be observed prior to 20 April in a given year, removal will be suspended, and in subsequent years the ending date will be revised accordingly. This action will preclude starvation loss of raven chicks, but reduce our ability to target removal of offending ravens, i.e. those foraging in sage-grouse habitat.

The researchers will estimate the number of ravens taken per baited egg using an energetics model developed by Wildlife Services (Taylor and Stahl 2018). The model incorporates several variables that affect a raven’s caloric need (e.g. ambient temperature), and raven behaviors (number of eggs consumed on site or cached) to derive mortality estimates. Thus, during the baiting period, ODFW or their agent will populate the model on a weekly basis, imputing the following required metrics: state where baiting occurs, month of baiting, average daily maximum and minimum temperatures, average percent cloud cover, type of clouds present, number of eggs present at bait sites, number of eggs recovered at bait sites, and whether caching behavior was observed on trail cameras. In each year of adult raven take, if implemented, weekly reports of take will be generated from this model, and removal will cease when estimated take approaches 400 ravens.

To conform to BLM land use plans, bait stations on BLM lands will not be constructed on Wilderness, Wilderness Study Areas, Areas of Critical Environmental Concern, or in Visual Resource Class I areas in BLM's Baker Resource Management Plan area. ODFW will coordinate directly with the BLM to identify potential bait station locations on BLM-managed lands and confirm they and all associated baiting activities are in conformance with local BLM land use plans.

5.2.2.2 Reducing Exposure to Non-targets

Crows and magpies may be exposed to eggs treated with DRC-1339 if ravens cached these eggs and crows or magpies raided those food caches. To reduce this likelihood, ODFW or their sub-permittees will use the methods described above to reduce the potential for egg-caching by ravens. In addition, applicators will remain in close proximity to baiting sites and observe using binoculars to determine if ravens are potentially caching eggs and reduce the number of treated eggs placed at each site if caching is documented.

6 Conformance with BLM Land Use Plans

Roughly 33% of the Baker PAC and 76% of the Cow Lakes PAC overlay BLM land. The Baker PAC falls within the Baker Resource Management Plan (BRMP) area and the Cow Lakes PAC falls within the Southeast Oregon Resource Management Plan (SEORMP). Both RMPs were amended in 2015 by the Greater Sage-grouse Approved RMP Amendments (ARMPA; BLM 2015). Both the nest removal and, potentially, placement of bait stations with DRC-1339-laced eggs proposed in this study, could be conducted on BLM lands.

The BLM land use plan (BLM 2015) places limits on human activities in seasonal sage-grouse habitat. The proposed actions will not occur during restricted times to avoid disturbance to breeding sage-grouse (i.e. two hours before sunset to two hours after sunrise March 1 through June 30 within 1.0 mile of occupied leks). The activities do not involve off-road vehicle use, chainsaw use, or other loud, disruptive actions (i.e. sound and light beyond background levels, or nearness of humans to sage-grouse) and as such would not be expected to negatively affect sage-grouse life-cycles or behavior; therefore, the actions would be in conformance with the RMP. Bait station placement would also be in conformance with the BRMP because they would not be placed in special management areas or areas with high visual resource values. ODFW will coordinate directly with the BLM to identify potential bait station locations on BLM-managed lands and confirm they and all associated baiting activities are in conformance with local BLM land use plans.

7 Common Raven

The common raven is among the most widely distributed bird species in the world, occurring in major portions of North America, Europe, Asia, and North Africa (Boarman and Heinrich 2020). They are essentially non-migratory, although local and widespread movements may occur depending on season, age, and breeding status (Goodwin 1986). Typical clutch size is between 3 and 7. Immature birds that have left their parents form flocks with non-breeding adults. These flocks tend to roam and are relatively loosely knit (Goodwin 1986).

Ravens are omnivorous and opportunistic; they feed on carrion, garbage, crops, eggs, birds, small mammals, amphibians, reptiles, fish, and insects (Boarman and Heinrich 1999). In many areas of the North American west, the raven is as an indicator of human disturbance. It is often associated with garbage dumps, sewage ponds, roads and highways, agricultural fields, urbanization, and other typical signs of human-altered landscapes (Boarman 1993, Kristan III and Boarman 2003, Coates et al. 2014a;b, Howe et al. 2014, O'Neil et al. 2018). For example, Coates et al. (2014a) found that the probability of raven occurrence was approximately 25% greater within 2.2 km of transmission lines and 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 (Coates et al. 2016).

Supplemental food and water sources such as garbage, crops, road-kills, etc., may give the raven an advantage over other less opportunistic feeders and appear to have allowed the raven population to increase rapidly in some areas. Ravens also take advantage of human-made infrastructure for nesting and perching. Coates et al. (2014b) found that ravens have a higher probability of nesting near human-altered and fragmented landscapes. 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 nonexistent or uncommon (Howe et al. 2014). In Wyoming, over 95% of raven nests were on human-built infrastructure (Harju et al. 2018).

Ravens utilize the landscape differently depending on their breeding status. During spring, breeding ravens focus their foraging activities within small geographies centered around their nest (average distance 0.8 - 1.8 km; Rösner and Selva 2005, Webb et al. 2012, Harju et al. 2018) in comparison to non-breeders that typically range from about 10 km up to hundreds of kilometers (Restani et al. 2001, Webb et al. 2012, Harju et al. 2018). The difference in these movement patterns can be explained by the need for breeding ravens to maintain close proximity to their nests and defend food resources within their territories. Non-breeders and ravens whose nests have failed, are not required to maintain site fidelity, and range widely in search of mates and/or to exploit a variety of food resources, including those associated with humans (Heinrich et al. 1994, Restani et al. 2001, Webb et al. 2012). If breeding raven territories are co-located with sage-grouse nesting habitat, ravens may disproportionately depredate sage-grouse nests as a result of their concentrated foraging efforts (Kristan III and Boarman 2003, Marzluff and Neatherlin 2006, HWA Wildlife Consulting 2017).

Baker County, OR, encompasses mountains and river valleys, and a mixture of conifer forests and high shrub-steppe habitats. Anthropogenic subsidies for ravens are most obvious in Baker Valley which is bisected by Interstate 84, holds the county seat, Baker City, and is typified by farms, cropland, and small towns.

7.1 Population Size and Trend

The population size of ravens in the United States is estimated at 2.5 million individuals. The 50-year population trend for the United States is estimated at 2.87%/year increase (95% credible interval = 2.46-3.26%/year) and the annual rate of increase in the last 10 years (2005-2015) is estimated to be 3.46%/yr (95% C.I. = 2.61-4.29%/yr) (Sauer et al. 2017). Across the Great Basin (an area including sagebrush ecosystems in Idaho, Nevada, and portions of Oregon and California), raven density was estimated at 0.54 ravens/km^2, corresponding to a population estimate of 403,346 ravens (Coates et al. 2020). OSU, ODFW and Service personnel conducted raven point count surveys in the Baker PAC during the springs of 2016-2020 using 10-minute point counts (described in Dinkins et al. 2012 and O'Neil et al. 2018). These data yielded an estimate for raven density in the Baker PAC of 0.44 ravens/km^2, which corresponds to a population estimate within the Baker PAC of 596 ravens.

Survey data collected during the 2018 breeding season in the Baker PAC area yielded a raven nest density of approximately 0.035 nests per km^2 equating to about 48 nests in the Baker PAC, however this estimate may be low based on limitations associated with detectability and access to private lands (L. Perry, pers comm.). In other areas raven territory size ranges from 5.1 – 40.5 km^2 (Boarman and Heinrich 2020), which would equate to 33 – 267 potential territories within the Baker PAC. Howe et al.

(2014) measured the average distance between raven nests in sage-grouse habitat at approximately 5.0 km, which would equate to 70 potential territories within the Baker PAC. Given this variability, and because measurements within the Baker PAC of densities at the lower end of this range, ODFW has proposed take of ≤ 100 nests annually to reduce the impact of raven predation on sage-grouse nests and improve sage-grouse nesting success.

8 Greater Sage-Grouse

Greater Sage-Grouse is a species of conservation concern, inhabiting 11 western states and 2 Canadian provinces. Within Oregon, sage-grouse occur within eight eastern counties. Their distribution and abundance in western North America has declined over the last century (Schroeder et al. 2004, Connelly et al. 2011a, Garton et al. 2011, Nielson et al. 2015), which has prompted multiple petitions to the Service to list the species as Threatened or Endangered (U.S. Fish and Wildlife Service 2015). In 2015, the Service decided that Greater Sage-Grouse do not warrant protection under the ESA (U.S. Fish and Wildlife Service 2015).

8.1 Population Size and Trend

Range-wide, sage-grouse have experienced long term population declines, with an estimated 30% decline since 1985 (Nielson et al. 2015). The 2020 estimated sage-grouse population in Oregon is 52% below the population in 2003, approximately 30,000, which serves as a baseline for management (Oregon Department of Fish and Wildlife 2020). Sage-grouse populations are characterized by population cycles driven by multiple factors including habitat quality, precipitation, human land use, and potentially predation pressure (Connelly et al. 2011a, Garton et al. 2011). As of spring 2016, statewide sage-grouse populations had been increasing for three consecutive years, however population trajectories remain variable at smaller spatial scales (Oregon Department of Fish and Wildlife 2016). The 2020 estimated statewide population of 14,068 individuals (95% CI: 12,897 – 15,238 individuals) represents a 1.7% increase from 2019 after three consecutive years of statewide population decline since 2016 (Oregon Department of Fish and Wildlife 2020). Baker County is one area of considerable concern. Historical data indicate sage-grouse populations were higher in the mid-20th century as compared with the early 21st century. Current data indicate that sage-grouse populations in this area have declined by approximately 75% since 2005, and have not exhibited a recovery similar to those observed in populations throughout the remainder of the state, since the previous population low in 2013 (Figure 4). The 2020 population estimate for the Baker PAC is less than 400 individuals (ODFW, unpublished data). This population may be particularly vulnerable because it is geographically isolated from the other sage-grouse populations in Oregon.

8.2 Threats to Sage-Grouse

In 2013, the Service identified threats, conservation objectives, and established Priority Areas for Conservation (PACs) to further range-wide sage-grouse conservation (U. S. Fish and Wildlife Service 2013). PACs are geographic zones necessary to maintain redundant, representative, and resilient

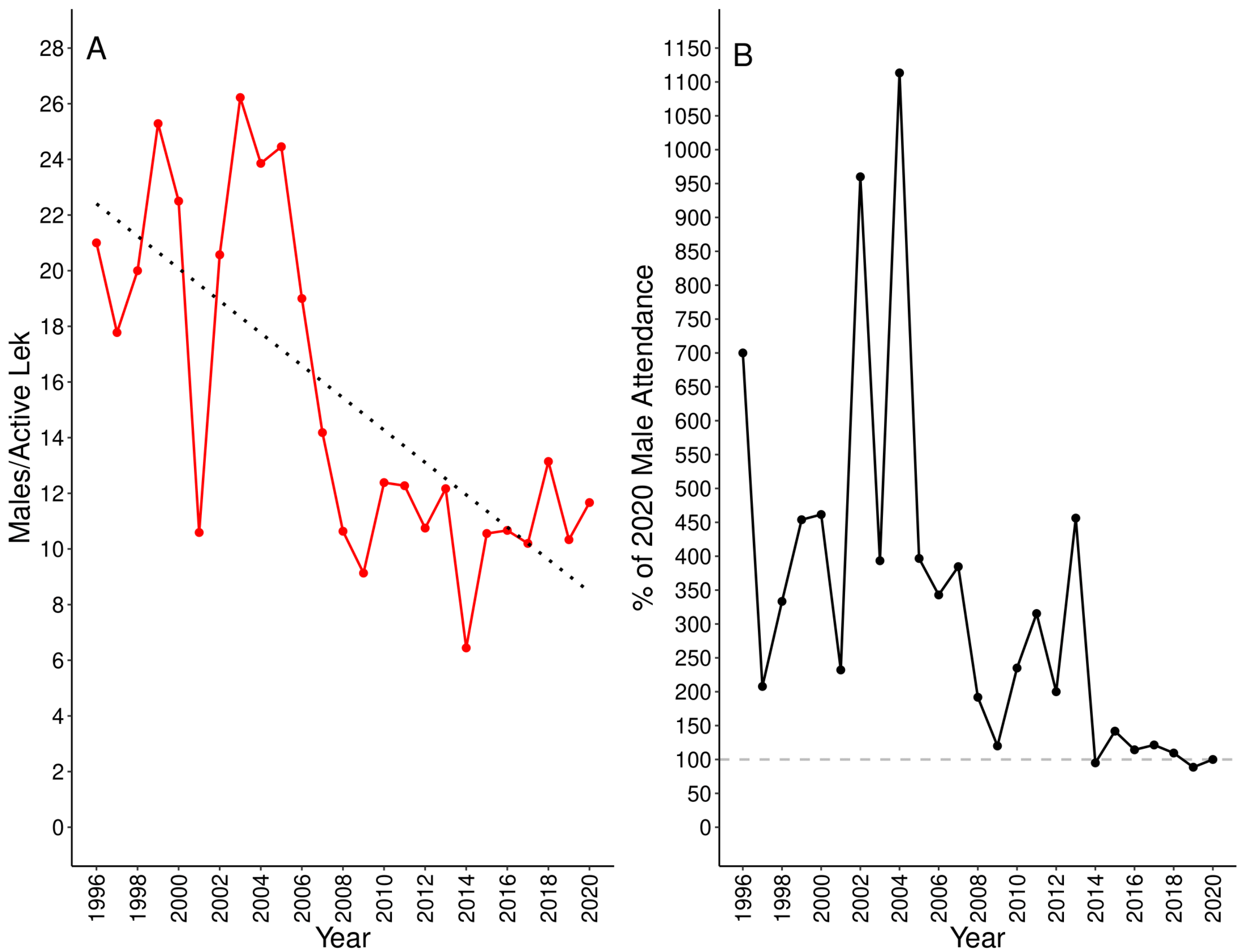

Figure 4. Greater Sage-Grouse population trend in the Baker PAC, 1996 – 2020. A - Change in average Greater Sage-Grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2020 male attendance (for a subset of complexes counted in both years t and 2020).

populations; they were identified by states, were adopted by the Service, and represent the most important areas on the landscape needed for maintaining healthy sage-grouse populations. Habitat loss is the primary threat to sage-grouse in Oregon, resulting from three interrelated mechanisms: juniper encroachment, invasive annual grasses, and wildfire (Oregon Department of Fish and Wildlife 2011, Sage-Grouse Conservation Partnership 2015). Other threats that may be important, though localized, include habitat fragmentation, or a reduction in quality due to: (1) multiple types of development (urban and ex-urban development, renewable energy, electrical and natural gas transmission lines, mining, roads, and other infrastructure, like communication towers); (2) sagebrush elimination and agricultural conversion; (3) improper grazing management (including both legacy effects of past management and current grazing regimes); (4) recreational uses (e.g. off-highway vehicles); (5) fences; (6) isolated or small population sizes; and (7) free-roaming equids (Sage-Grouse Conservation Partnership 2015).

Additional circumstances that could negatively impact sage-grouse include: (1) climate change; (2) drought; (3) West Nile virus; (4) excessive flooding; (5) predation; (6) hunting; (7) insecticides; (8) sagebrush defoliator moth; and (9) other noxious weeds (Sage-Grouse Conservation Partnership 2015).

In certain areas ravens may constitute the primary predator of sage-grouse nests (Coates et al. 2008, Lockyer et al. 2013). In areas with sufficient intact nesting cover, and low raven densities, this predation should not impose a limiting factor on sage-grouse population growth (Hagen 2011). However, when raven populations in an area exceed a threshold, nest predation may negatively affect sage-grouse population growth (Coates 2007, Dinkins et al. 2016, Peebles et al. 2017, Coates et al. 2020). Coates (2007) observed a 49% reduction in nest success of sage-grouse in areas where raven abundance exceeded 7 ravens per 10 km transect. Coates and Delehanty (2010) found that odds of sage-grouse nest failure increased 7.4% with every additional raven observed per 10 km transect. Dinkins et al. (2016) observed a >100% increase in sage-grouse nest success (from 24.8% to 51.3%) after experimentally reducing raven densities from 0.4 – 0.5 ravens/km^2 to 0.2 –0.3 ravens/km^2. Peebles et al. (2017) determined that decreases in raven density, in combination with cooler temperatures and more precipitation during brood-rearing were associated with increased lek counts after a one-year time lag; raven densities were reduced by 50% during this study. Considering all relevant studies and to guide management decisions, Coates et al. (2020) highlight a raven density of 0.40 ravens/km^2 as an important ecological threshold because when local raven populations exceeds this density, sage-grouse nest survival is below average. It should be noted that Coates et al. (2020) consider 0.40 ravens/km^2 a conservative point of bifurcation because even sparser densities of ravens can have deleterious impacts on sage-grouse, particularly in areas with unfavorable habitat conditions.

Loss and degradation of concealment cover (e.g., sagebrush cover and grass height) combined with increasing raven abundance interactively reduce sage-grouse nest success. For example, sage-grouse nests with greater sagebrush cover were less likely to be depredated by a raven (Coates and Delehanty 2010). Sage-grouse populations in severe decline may benefit from raven removal followed by identification of long-term management actions to keep raven abundance lower, while concurrently improving sage-grouse habitat quantity and quality.

Badgers (*Taxidea taxis*), fox (*Vulpes* spp.), and coyotes (*Canis latrans*) are other predators of sage-grouse and/or their nests (Danvir 2002, Slater 2003, Coates and Delehanty 2004, Mezquida et al. 2006, Coates et al. 2008, Orning 2014). Unlike ravens, however, these predators are generally not the primary predator affecting sage-grouse, have not undergone exponential population growth in recent decades, and/or are already controlled by APHIS Wildlife Services program to protect agricultural interests. As a result, and in combination with experimental evidence documenting the effectiveness of raven control on sage-grouse nest success, recruitment, and population growth (Dinkins et al. 2016, Peebles et al. 2017), ravens are the focal species for predator management to benefit sage-grouse.

8.3 Sage-grouse Threat Reduction Efforts

The Baker Local Implementation Team (LIT)[1],completed a Comprehensive Sage-Grouse Threat Reduction Plan (hereafter, TRP; Baker Sage-grouse Local Implementation Team 2017) that serves as a local work plan to guide activities aimed to reverse the declining sage-grouse population trend in Baker County, with an initial focus on the Baker PAC. This plan is intended to be a "living document" to allow prioritized actions to be adapted with the emergence of new information, shifts in ecological condition, and funding opportunities. The Baker LIT recognizes that funding opportunities in out-years are uncertain and that future projects identified in this plan are contingent on federal and state budget allocations. However, the plan serves to prioritize work in terms of scope and geography, so that initial planning can occur in advance of emerging funding opportunities so they can be utilized expeditiously, efficiently, and in a manner that will likely have the best outcome for sage-grouse populations in the Baker PAC. To that end, in 2019, The Baker LIT was awarded a $6.1 million Focused Investment Partnership (FIP) grant from the Oregon Watershed Enhancement Board (OWEB) to implement a program to reduce threats to sage-grouse as outlined in the TRP.

Many of the aforementioned threats to sage-grouse are present in the Baker PAC and are likely operating in concert to limit local sage-grouse populations. The population decline in the Baker PAC has exceeded thresholds established in the ARMPA (BLM 2015); requiring an interagency team to conduct a causal factor analysis (CFA) in order to best identify factors most responsible for the decline and practical actions to ameliorate those factors. The CFA for the Baker PAC was completed in 2017 (available from the OR-WA BLM Office upon request).

This process identified several actions that BLM undertook to address factors unique to the Baker PAC. In particular, in 2018 the BLM established a temporary emergency seasonal closure around a lek located within the Virtue Flat Off-Highway Vehicle (OHV) area to eliminate disturbance to sage-grouse during the sensitive breeding season. This closure extends from March 1- June 30 annually and incorporates the mandatory 2-mile buffer around leks (however, where natural features serve to reduce disturbance, the exact buffer is less). The temporary emergency seasonal closure has been renewed annually. The need for further action in the form of a permanent seasonal closure will be informed by vehicle use data that is currently being collected using vehicle counters. The traffic counters that were installed in fall 2018 can detect vehicle use (e.g. ATVs, quads, motorcycles, jeeps, 4x4s, bicycles) and will be positioned for 5 years on developed trails, and in particular, at the staging area, entrance gates, and at the OHV lek location. This information will be analyzed to identify where recreational use is concentrated within the OHV use area. If a permanent seasonal closure is deemed necessary, BLM will initiate a NEPA process and will incorporate the traffic data in formulating action alternatives. The BLM also posted educational

[1] The Baker Local Implementation Team includes personnel from ODFW, NRCS, BLM, Service, Union and Baker Counties, Powder Basin Watershed Council, and Tri-County Cooperative Weed Management Area, as well as elected officials and private landowners.

information about trash "pack in/pack out" requirements, fire prevention, weed management, and general sage-grouse education at the OHV staging area. The BLM provided public outreach to inform OHV users of the re-designation of areas previously open to cross-country travel that are now restricted to existing routes (as stipulated in the 2015 Sage-Grouse ARMPA). Outreach included ads placed in the 2017 and 2018 ODFW Hunting Regulations; signage at the staging area informing users of this change in regulations; and updated information on the BLM website. Invasive weed containment activities are ongoing with initial focus on the OHV staging and the BLM is coordinating with the Baker LIT to provide an OHV washing station to reduce the spread of invasive vegetation by recreational vehicles.

In order to reduce anthropogenic subsidies that may contribute to sage-grouse nest predation, the BLM installed perch deterrents at the National Historic Oregon Trail Interpretive Center which is located in the Baker PAC. The BLM also leases a site to the Powder River Sportsman Club (PRSC) which is used by the public and law enforcement for training and target practice. Several stipulations to reduce risk to sage-grouse were incorporated into the PRCS lease when it was renewed on a short-term basis in 2019. Specifically, the BLM required PRSC to restrict construction of structures that may provide perching opportunities for avian predators; install raven/raptor perch and nest deterrents on existing perching/nesting substrates, as identified; eliminate food sources to reduce predator attractants; avoid disruptive activities and limit noise to <10 decibels (above ambient sound) during sage-grouse breeding and nesting; cover all pits and tanks to reduce sage-grouse mortality; and use locally-sourced native plants in restoration/seeding projects, as applicable and available.

The BLM has continued to create management opportunities for sage-grouse by initiating the Habitat Assessment Framework (HAF) for Baker. The HAF is a habitat assessment to inform managers where to implement conservation actions that might benefit sage-grouse. This approach allows managers to integrate conservation actions at a project level that make sense at the population level. The Baker HAF is scheduled to be completed in or after 2022 (BLM, pers. commun.).

The BLM is an active partner in the Baker LIT and has implemented invasive annual grass and noxious weed surveys and/or control on over 10,000 acres in the Baker PAC since 2015. These efforts are coordinated with other LIT partners to ensure that treatments are contiguous across private-public land boundaries.

In general, the proximal cause of sage-grouse nest failure is primarily predation by avian or mammalian predators (Coates et al. 2008). However, ultimately the probability of nest success is dependent on the interaction between vegetation surrounding the nest sites and the density and composition of local predator communities (Connelly et al. 2011a). Nest site vegetation impacts the probability of nest success by providing visual cover to incubating hens (Connelly et al. 2011b), and by providing important forbs for hen nutrition which both facilitate the production of viable eggs (Barnett and Crawford 1994, Schroeder 1997) and support hen body condition during the incubation period (Connelly et al. 2011b). Any effort to improve sage-grouse nesting success in an area, and subsequently population growth, should include efforts to improve sage-grouse nesting habitat, through the promotion of sagebrush cover, under which hens predominately nest, perennial bunchgrass cover and height which provides vertical cover for nesting hens, and forbs, to promote hen nutrition and body condition. Efforts of these types have been implemented or are underway in the Baker PAC (Baker Sage-grouse Local Implementation Team 2017). Since receiving OWEB FIP funds in 2019, the Baker LIT has invested over $2.2 million towards weed inventory (56,000 acres); annual grass treatments (>3,300 acres); treatment of other noxious weeds (>2,600 acres), seeding (850 acres), as well as other habitat restoration projects. Sage-grouse evolved with their predator community, thus in areas of intact habitat, with natural predator densities, predation should not pose a limiting factor to sage-grouse populations. However, in areas of degraded habitat, and/or areas with artificially increased predator densities, predation may negatively impact sage-grouse population trajectories (Hagen 2011), and raven removal may be warranted (Coates and Delehanty 2004, Coates et al. 2020).

The aforementioned TRP and CFA clearly identified areas in the Baker PAC where degraded habitat may be compounding the impacts of unnaturally high predator densities, as well as strategies to address these underlying habitat concerns. These planning documents were foundational to the development of a Strategic Action Plan (Baker Sage-grouse Local Implementation Team 2018), resulting in the $6.1 million OWEB grant. With OWEB funding secured, the Baker LIT, over 3 biennia (2019-2025), aims to: (1) increase landowner enrollment in voluntary conservation programs, including the development of grazing management plans; (2) reduce further habitat loss and wildfire risk by treating and preventing invasive vegetation and through strategic fuel breaks; (3) improve existing habitat by enhancing understory vegetation and mesic (late brood-rearing) habitat; (4) reduce sage-grouse nest depredation by removing human subsidies that support artificially high predator abundances; and (5) address other potential risks to sage-grouse, such as West Nile virus.

9 Analysis of the Alternatives

9.1 Geographic Areas Analyzed

We analyzed the environmental effects of the alternatives within both the Baker PAC (where lethal take is proposed) and Cow Lakes PAC (where subsidy removal is proposed), and at the scale of the Great Basin.

The Baker PAC is the area from which raven nests or adults would be removed (Figure 1). Our selection of the Baker PAC for the fine-scale analysis was informed by recently collected raven movement data. Ten adult ravens captured within the PAC or within Baker County in the vicinity of the PAC were marked with GPS transmitters and monitored from January 2018 through the 2019 migration season. Preliminary GPS data show that seven of the ravens caught in Baker County were also located in Baker County during the breeding season. In contrast, four birds with transmitters traveled outside Baker County (e.g. to neighboring Union County, Idaho, or Nevada) during winter before returning for the breeding season. One raven did not return to breed in Baker County and instead traveled to Utah during the winter and Washington during the breeding season. Two other telemetered birds traveled to southern Nevada for the winter but did not survive to the following breeding season. Other data suggest that ravens can be both locally- or widely-ranging depending on the life stage or season, with daily foraging distances of 0.30 to 2.8 km (Roth et al. 2004, Rösner and Selva 2005, Harju et al. 2018), movements between foraging and roosting areas of up to 40 km (Heinrich et al. 1994), and juvenile dispersal distances of 13.1 to 23.4 km (Webb et al. 2011). These studies suggest that lethal removal of ravens in the Baker PAC could influence raven population numbers outside of the Baker PAC, and that dispersal into the Baker PAC area from ravens outside of the PAC area is likely.

Typically, when considering take permits for migratory birds, the Service is primarily concerned with population-level effects on the species being taken, e.g. effects at the flyway- or Bird Conservation Region-level (BCRs; NABCI 1998), unless local populations are considered unique. Studies, including the transmitter data summarized above, suggest that ravens do not have unique or local populations in the western United States and in fact may move regularly across large areas (Boarman and Heinrich 1999). Stiehl (1978), for example, documented ravens traveling up to 480 km from other seasonal locations throughout Oregon and Nevada to a winter roosting location in southeastern Oregon.

Analyses in Fleischer et al. (2008) derived comparisons of mitochondrial DNA of ravens in the western Mojave Desert with ravens across large areas of California and Nevada (Central Valley or northern California, southern California, northern Nevada, and eastern Mojave). He found genetic structure distinguishing these regions, suggesting generally little interchange of ravens among regions; however their data also suggest that the recent sudden population increase of ravens in the western Mojave Desert is at least partly the result of immigration from southern California or Central Valley populations rather than from intrinsic population growth. More recent analyses show a broad intermixing of genetic signatures that represent two, once independent but now intergraded, populations of ravens across the western United States; gene flow appears to be fluid, extensive, and pointing toward a "shared current evolutionary trajectory" (Boarman and Heinrich 2020).

The extent to which ravens regularly move between populations will continue to evolve with ongoing genetic research and studies using ravens with transmitters. Current information suggests, however, that it is not unreasonable to use the Great Basin as a geographic area within which to examine impacts on a connected population of ravens. It also is the area within which raven and sage-grouse interactions are being examined by others, and thus there is logic to being consistent with these efforts (Coates et al. 2020).

Thus, in our population models of ravens, we evaluated whether or not implementation of any of the alternatives would cause an irreversible, declining population trend for ravens at the Great Basin scale; such a predicted outcome would be a significant effect to ravens.

9.2 The Raven Take Analysis

We modeled the effects of the alternatives on ravens using a prescribed take level (PTL) model (Runge et al. 2009) and systems dynamics simulation (Ford and Ford 1999); we evaluated those effects at both the Baker PAC and Great Basin scales (Appendix B). The model is simple in that it assumes immigration and emigration do not influence the population being modeled. If ravens are removed from the Baker PAC, immigration from outside is likely to result in some replacement of those ravens taken. Thus, this "closed population" assumption is unrealistic for small, modeled populations that are encompassed by a relatively large and fluid population, such as is the case with the Baker PAC. However, the model does provide a starting point for evaluating population level effects at all scales, and yields 'conservative' results relative to eventual population dynamics within the Baker PAC. The population model more likely reflects actual population dynamics at the much larger Great Basin scale. Appendix B describes the modeling approach and results in greater detail.

Research and locally collected data suggests that the maximum number of raven nesting territories in the Baker PAC likely ranges between 50-100 nests (see Section 6.1). Our model assumed a baseline of 78 nests in the Baker PAC, generated from randomly uniform distributions ranging from 50-100 nests and representing potentially 78 pairs of ravens and their nests (Appendix B). The nest removal portion of our population model estimated that in any given year it was reasonable that up to 70% of these 78 nests, or up to 55 nests, might actually be accessible and could be removed. In essence, we modeled the effect of denying 55 breeding pairs the opportunity to successfully breed, regardless of whether or not they attempted to renest after their initial nest was removed. This might appear to be at odds from the proposed take level throughout this document of "up to 100 nests per year". However, the proposed take considers that a proportion of the 55 breeding pairs will attempt to renest at least once after their initial nest is destroyed and that the second or third nests of the pair will also be destroyed. The higher take threshold of 100 nests per year in the Baker PAC is a liberal, maximum amount that we would consider permitting under any scenario involving nest removal and, importantly, includes re-nesting attempts within the year.

The baseline raven population we used in our model for the Great Basin is estimated at 403,346 (derived from estimates in Coates et al. (2020). For the Baker PAC we estimated the population at 596, generated randomly from uniform distributions ranging from 500-1,000 ravens (Appendix B); this approximation is very close to the estimate (600) derived from locally-collected raven density information (Appendix A).

9.3 Alternative 1: Deny the Permit

Under this alternative, we would not issue a scientific collecting permit. Permits under the MBTA and our implementing regulations may be denied for any of several administrative reasons, or because the proposed activity may potentially threaten a wildlife or plant population, including ravens (See Section 3; 50 CFR §13.21). This alternative is reasonable to consider, as the Service is required by regulation to determine if an application meets issuance criteria and denying a permit pursuant to ODFW's permit application is a potential decision.

9.3.1 Effects on Raven Populations

If the Service chooses this alternative, ODFW's proposed study would not proceed, and the Service's decision would result in no effect on current raven population trends or sizes within either the Baker PAC or the Great Basin. The Baker PAC would continue to have about 74 ± 2 (95% CI) raven nests with about 850 ± 170 (95% CI) individuals in year 5, and a raven density of 0.62 ravens/km^2 (Table 1; Appendix B). Within 15 years, the number of raven nests in the Baker PAC would remain at the estimated carrying capacity for breeding pairs, 68 ± 2 nests (95% CI), and the raven population would be expected to continue to grow to 960 ± 48 ravens (95% CI) with a density of about 0.71 ravens/km^2. At the Great Basin scale, the population would presumably continue to grow to some threshold determined by the carrying capacity of the region, which is likely now determined by human population growth across the west.

It is uncertain whether or not the planned food subsidy and artificial nesting structure removals in the Cow Lakes PAC would continue as proposed under this alternative (non-lethal methods do not require a MBTA permit). If they did not occur, ravens would be unaffected in the Cow Lakes PAC. If the non-lethal aspect of the study were to continue, a variety of non-lethal methods will be used to reduce raven densities in this PAC, including removal of road-killed animals, reducing access to carcasses in livestock carcass stations, and removing artificial nesting structures. The goal of reducing access to food subsidies is to negatively affect raven reproductive success; increased competition for food might also lead to emigration by ravens reducing their densities in the Cow Lakes PAC. Removing artificial nest structures might also lead to competition for nest sites and further emigration. Raven density might go down, as ravens dispersed to areas where food subsidies might support more successful breeding outcomes.

9.3.2 Effects on Sage-Grouse

To the extent that the Baker PAC sage-grouse population is declining at least in part due to high raven densities, it is likely that their population will continue to decline under this alternative. Based on population modeling, the raven density after five years with no management action would approximate 0.62 ravens/km^2 in year 5 (Table 1) which is 50-60% times the raven density threshold above which sage-grouse nests success would be expected to decline (Coates et al. 2020). Raven depredation pressure might be so severe as to cause the eventual extirpation of sage-grouse from this PAC. On the other hand, if ravens have no effect on sage-grouse populations then this Service decision would not influence the negative population trend of sage-grouse in the Baker PAC.

A large targeted restoration effort to enhance and restore sage-grouse habitat and population in the Baker PAC is currently underway. These restoration activities will continue under Alternative 1 and sage-grouse recovery in response to these efforts are expected to occur, but this recovery will not be immediate due to the long time frames for habitat improvements to be achieved. It is possible that sage-grouse populations will continue to decline in the Baker PAC while restoration actions take effect.

If subsidy removal in the Cow Lakes PAC were to continue regardless of our decision to not issue a permit under this alternative, then sage-grouse in that PAC might initially experience greater predation pressure by ravens, deprived of food subsidies. Over time, with fewer food resources available, ravens might disperse from this region and relocate where food subsidies are more abundant. This would presumably improve sage-grouse nesting success in the Cow Lakes PAC.

9.3.3 Effects on Other Species

Under this alternative, there would be no risk of non-target effects from the application of DRC-1339. However, it is likely that high raven populations also have a negative population effect on these species as well as on sage-grouse; populations of these species might also suffer from some degree of depredation by ravens, or competitive interactions for food or nest sites (black-billed magpies and American crows, for example; McKinstry and Knight 1993, Wilmers et al. 2003) when ravens are at the density estimated in the Baker PAC. In habitats across the western U.S., raven densities are higher in the presence of human made structures (O'Neil et al. 2018), and several studies demonstrate that ravens in high densities decrease nest success of several species of birds and survival of other species (desert tortoise; Kristan III and Boarman 2003). In the sagebrush community, sagebrush-obligate species suffer higher rates of nest depredation in fragmented habitats (Gilbert and Chalfoun 2011, Mutter et al. 2015), due at least in part to ravens (Vander Haegen et al. 2002); however, this effect has not been noted in every study (Hethcoat and Chalfoun 2015). Thus, no action is likely to result in a growing raven population and higher predation rates on other locally-breeding birds. In general, populations of other bird species under this option might perform worse than if the Service chooses Alternative 2, 3, or 4.

Other sagebrush-obligate bird species breeding in the Cow Lakes PAC that might be subject to raven predation as well, might also experience the same short- and long-term effects as sage-grouse, i.e., initially more intense nest predation, followed by a reduction over time as ravens dispersed. Any short-term effects from increased predation pressure are unlikely to have population-level effects over the long-term, because the Cow Lakes area is small relative to the overall distributions of all bird species that occur there.

Other nest predators, for example black-billed magpie and American crow, might experience increased competition for food resources in the short-term as subsidized ravens compete with them for fewer food resources. And, these other scavenging species might also experience small population declines within the Cow Lakes PAC, if their current population numbers are also supported by anthropogenic subsidies.

9.4 Alternative 2: Issue Permit for Nest Take Only

Under this alternative, the Service would issue the scientific collecting permit authorizing the take of nests only. This would be the same as the proposed study, Scenario 1 (see Section 5.1), but without the authorization for adult raven take if nest take-only failed to achieve improved sage-grouse productivity and reduced raven occupancy in raven territories. As in the study proposal, nest take would be limited to inactive or active nests with eggs and not include the take of nests with nestlings. A maximum of 100 nests per year would be authorized for removal for three years under this alternative. It should be noted that under this alternative, a separate take permit (either a Depredation or Scientific Collecting Permit) would be required should ODFW propose to resume lethal removal of ravens after their study has concluded and this new permit application would prompt separate NEPA review.

Table 1: Predicted population outcomes to ravens in the Baker PAC of implementing alternatives assuming a baseline estimate of 78 nests and 596 adult ravens.

Alt.	Description	Adaptive Management Scenario	Year[1] 1	2	3	4	5	15
1	Deny Permit	NA	0,0	0,0	0,0	0,0	74 (± 2), 850 (± 170) Density ≈ 0.62 ravens/km^2	68 (± 2), 960 (± 48) Density ≈ 0.71 ravens/km^2
2	Nest Take Only	NA	55,0	55,0	55,0	0,0	2 (± 2), 671 (± 154) Density ≈ 0.49 raven/km^2	67 (± 12), 954 (± 56) Density ≈ 0.70 ravens/km^2
3a	Proposed Action	Nest take only	55,0	55,0	55,0	0,0	2 (± 2), 671 (± 154) Density ≈ 0.49 ravens/km^2	67 (± 12), 954 (± 56) Density ≈ 0.70 ravens/km^2
3b		Yr 1-2 nest take; Yrs 3-4 adult take	55,0	55,0	0,400	0,400	27 (± 16), 185 (± 82) Density ≈ 0.14 ravens/km^2	64 (± 14), 762 (± 290) Density ≈ 0.56 ravens/km^2
4	Adult Take Only	NA	0,400	0,400	0,400	0, 0	74 (± 2), 144 (± 80) Density ≈ 0.11 ravens/km^2	68 (± 2), 692 (± 362) Density ≈ 0.51 ravens/km^2

1 - Numbers in years 1 – 4 correspond to #Nests removed, #Ravens removed. Numbers in years 5 and 15 are population estimates for #nests (± 95% confidence interval), #adult ravens (± 95% confidence interval).

9.4.1 Effects on Ravens

In each year, the proposal is to remove all nests found in the Baker PAC. It is likely, however, that some nests will escape detection or be inaccessible. In addition, we assumed that each year some small, but unknown number of breeding ravens will attempt to re-nest after losing their initial nest. By removing up to 100 nests per year for three years, the number of nests in the Baker PAC would drop considerably by year 5 to 2 ± 2 nests (± 95% CI), yet the number of adult ravens would slightly increase from the current population estimate to 671 ± 154 ravens at year 5 (± 95% CI) equating to approximately 0.49 raven/km^2 in the Baker PAC (Table 1, Appendix B). However, within 15 years, the number of nests in the Baker PAC would rebound to 67 ± 12 nests (± 95% CI) and the number of ravens would grow to 954 ± 56 ravens (± 95% CI) and a density of 0.70 ravens/km^2, exceeding the current raven population estimate in the PAC (Table 1, Appendix B).

If some raven pairs are persistent re-nesters, ODFW has proposed to use egg-oiling to deter them from re-nesting (Section 5.2.1). Oiled eggs prevent gas exchange through the shell, essential for embryo development, and thus the eggs fail to develop and do not hatch. The usual effect on the adult pair is that they incubate well-beyond the hatch date, and then eventually abandon their territory. The intent is to prevent a clutch from hatching, thereby eliminating the need for constant feeding of nestlings with high energetic demands, and thus less predation pressure on local sage-grouse. The foraging behavior of a pair of birds in a prolonged phase of incubation is uncertain, , however they will not have to meet increased energetic demands from a growing brood, and thus the expected effect is that their predation pressure on local sage-grouse would be less. And, adults would not be productive in that or subsequent years if egg-oiling continued to be used.

Removal of approximately 70-100% of the raven nests in the Baker PAC would have no discernible impacts to the Great Basin raven population (Figure 5). The population model suggests that even under scenarios including adult take in the Baker PAC, and including other raven take authorized in the Great Basin, the raven population in the Great Basin will continue to increase in the short-term and eventually stabilize at a higher population than it is now (Appendix B). Given that nest removal in the Baker PAC has no effect on the long-term population of ravens in that PAC, and adult take in the Baker PAC has no discernible effect in the Great Basin, we assume that nest take alone in the Baker PAC will also have no effect on the Great Basin population of ravens.

In the Cow Lakes PAC, the effect on ravens of this alternative would be as described under the No Action alternative where the subsidy removal study proceeded as planned.

9.4.2 Effects on Sage-Grouse

The intent behind nest removal is to examine the effects on raven density or occupancy, and on sage-grouse. It is possible that sage-grouse will have higher productivity as a result of nest removal, because ravens without nests will forage more widely, away from their nesting territories in sage-grouse nesting habitat, and thereby apply less predation pressure on sage-grouse (Section 5). Under this scenario, raven density overall in the Baker PAC might be as high as 0.49 raven/km^2 in year 5 (and 0.70 raven/km^2 in year 15; Table 1), high enough to cause detrimental effects to sage-grouse productivity (Coates et al.

2020). Nonetheless, nest removal might cause ravens to forage away from territories in sage-grouse habitat and concentrate their activities near areas of human subsidies where food is easier to find, e.g. the local landfill, near Baker City, or along the highway corridors and in agricultural land.

This research project is occurring in the context of a large targeted restoration effort to enhance and restore sage-grouse habitat and population in the Baker PAC. If raven nest destruction induces a shift in raven foraging behavior, this could confer immediate relief from raven-caused depredation of sage-grouse nests and halt further sage-grouse declines while habitat restoration and raven subsidy removal activities have time to take effect. If ravens do not respond as predicted, they could continue to exert heavy predation pressure on sage-grouse, particularly because nest removal alone will not induce a change in the raven density in the PAC, and this would likely prevent sage-grouse recovery in the Baker PAC. Raven depredation pressure might be so severe as to cause the eventual extirpation of sage-grouse from this PAC. If ravens have no effect on sage-grouse populations then this Service decision would not influence the negative population trend in the Baker PAC.

In the Cow Lakes PAC, the effect on sage-grouse would be similar to that described under No Action, above.

9.4.3 Effects on Other Species

If ravens do alter their foraging behavior away from their nesting territories, other species of nesting birds might experience the same release from predation pressure as sage-grouse. However, it is also possible that local populations of other nest predators, for example black-billed magpie and American crow, might increase modestly as they experience decreased competition for food resources as failed-nesting ravens forage more broadly.

Removal of subsidies used by ravens in the Cow Lakes PAC may also influence other scavenging species (e.g. other raptors or corvids or small mammals like coyotes and ground squirrels) or those that use similar perching or nesting structures (e.g. other raptors) in that they, too, will have fewer available resources. Like ravens, these species might experience greater competition for food and/or nesting substrates and might disperse elsewhere or experience localized population declines. Golden eagles, which sometimes scavenge, nest in very low densities, and any eagles nesting in the vicinity will have many other sources of prey; they are unlikely to be affected by carcass removal.

Effects to other species in the Cow Lakes PAC resulting from Alternative 2 would be similar to those described for Alternative 1.

9.4.4 Other Effects

We considered the social interests that may be influenced by Alternative 2, including those that were identified during the public comment period for the February 2019 and January 2021 Draft EAs. Alternative 2 will not have a significant effect on individuals who wish to watch ravens in the natural environment because it is limited geographically and temporally, and because raven populations will continue to increase in the Baker PAC and more broadly during the nest removal action, and increase even more so, particularly once management activities cease. The proposed action aims to temporarily reduce the distribution and density of ravens in areas targeted to benefit sage-grouse and thus ravens will be available within other areas of the natural environment across the landscape for birdwatchers and others who enjoy them.

Some individuals primarily concerned about animal welfare and/or cultural concerns may consider the proposed action to be acceptable because of (1) lethal take is limited to egg destruction and not of nestlings or adult ravens; (2) the limited geographic and temporal scope of the lethal take activities; (3) the intended outcomes to benefit the rapidly decreasing sage-grouse population in the Baker PAC; (4) the scientific research and monitoring that define ODFW's study; and (5) the Baker LIT's past and ongoing efforts to address factors that may be exacerbating the effects of predation (e.g. habitat quality and anthropogenic subsidies; Baker Sage-grouse Local Implementation Team 2017). It is likely, however, that some segments of the public may oppose the Alternative 2 because they may find destruction of raven nests or eggs to be unacceptable.

9.5 Alternative 3: Issue Permit (Proposed Action)

Under Alternative 3, the Service would issue a scientific collecting permit for the study as described in the permit application submitted by ODFW. We would authorize take of up to 100 raven nests per year for three years (300 nests total), and the take of up to 400 adult ravens per year for two years (800 adult ravens, total) within Baker County, Oregon. The application proposes an adaptive management approach in which the requested take would either be: 1) nest removal only with a maximum take of 300 nests; or 2) nest removal combined with lethal removal of adults with a maximum take of 200 nests and 800 adults. The study design and objectives are described in Section 5.1. Under this alternative we would authorize a permit to achieve the goals stated on the application, without modification. If adult ravens were taken, then DRC-1339 would be applied either by ODFW or their licensed agents. See Section 5.4.2 above, for a description of this avicide and application methods. If DRC-1339 is used, any raven carcasses recovered following the application of the toxicant would be destroyed. As with Alternative 2, a separate take permit (either a Depredation or Scientific Collecting Permit) would be required should ODFW propose to resume lethal removal of ravens after their study has concluded and this permit application would prompt separate NEPA review.

9.5.1 Effects on Ravens

9.5.1.1 Baker and Cow Lakes PACs

We modeled the impacts to raven populations in the Baker PAC for both of the potential management scenarios under this adaptive management framework. Under the first scenario, should nest removal prove effective, nest removal would occur during years 1-3 of the project and the effect on the raven population would be identical to that described for Alternative 2. If egg-oiling is used for persistent re-nesting ravens, then the effects on ravens would be as described for Alternative 2 (Section 8.4.1).

Under Scenario 2 of this alternative, if nest removal is determined to be ineffective or the results on raven behavior or sage-grouse productivity are inconclusive after two years of nest removal, then adult raven take of up to 400 ravens per year would occur in years 3 and 4. In this scenario, our PTL model suggests that by year 5, the number of raven nests would be reduced to 27 ± 16 (± 95% CI) and the number of adult ravens would be reduced to 185 ± 82 (± 95% CI) with an expected density of about 0.14 ravens/km^2 (Table 1, Appendix B). Within 15 years, the number of nests and ravens would recover to 64 ± 14 (± 95% CI) and 762 ± 290 (± 95% CI), respectively, with an adult density of approximately 0.56 ravens/km^2 (Table 1, Appendix B).

In the Cow Lakes PAC we expect the effect on ravens from this alternative will be as described under the No Action alternative.

9.5.1.2 Great Basin

In this section we estimate raven population trends at the Great Basin scale under this alternative when combined with other authorized take across the western United States.

The Service authorizes take of ravens across the western United States to prevent depredation of crops, livestock, protected species, and for human health and safety. Table 2 summarizes raven take authorized by the Service and the numbers actually taken by permittees, from 2006 through 2017, across 7 western states; these states include a much larger area than, and wholly encompass, the Great Basin area we use to define our larger raven population area (see Figure 1 in Coates et al. 2020).

Slightly more than half of the ravens authorized were actually taken over these years (15,387 authorized v. 8,007 actually taken). The maximum take authorized in each state over these years varies considerably, from a low of 173 (Arizona, 2017) to 5,197 (Nevada, also in 2017). The maximum take ever authorized in each state (in any year), summed across states, was 19,561, while the sum of maximum ravens actually taken was 9,526. Adding 400 (that is, the maximum annual take proposed in this study) to the authorized sum yields 19,961, or roughly 20,000 ravens that might conceivably be authorized per year across the Great Basin during the course of this study. These numbers give us a reasonable range of values to use as a basis to estimate the effects on ravens in the Great Basin from issuing a scientific collecting permit to ODFW as proposed here combined with take authorized to other permittees.

The model we used assumes a starting population of 403,346 ravens (Coates et al. 2020), and an annual harvest rate (annual raven take) of between 1% and 10% (approximately 4,000 and 40,000 birds per year) of the population over 60 years. This range of harvest (1% and 10%, or 4,000 to 40,000 birds per year) is reasonable given the number of ravens that might be authorized, described above. Under the constraints of the model (constant estimated population growth rate of 0.305, no immigration or emigration, and others – see Appendix B), the raven population will continue to grow, reaching a plateau in 15 to 20 years as the population approaches the modeled carrying capacity, at about 590,000 ravens ± 65,847 (± 95% CI) (Figure 5).

Table 2: Authorized and Actual Common Raven Take in Western States from 2006 – 2017 [1]

	California		Nevada		Oregon		Washington		Idaho		Arizona		Utah		Sum	
Year	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**	**Auth**	**Actual**
2006	1465	877	2620	2384	900	246	281	3	170	114	370	82	17	0	5823	3706
2007	1793	1066	2820	523	900	133	268	2	170	78	370	72	15	0	6336	1874
2008	1897	1007	2170	2201	1195	513	250	1	170	109	510	92	50	1	6242	3924
2009	1906	839	2140	1797	890	360	256	10	170	42	380	90	1400	532	7142	3670
2010	549	492	1810	150	915	265	250	25	25	3	100	88	45	13	3694	1036
2011	2627	1258	4086	3062	2764	281	1199	118	845	103	278	48	2105	1515	13904	6385
2012	1966	755	3810	3287	190	801	250	69	275	193	514	163	2501	2169	9506	7437
2013	3316	724	4540	4209	995	678	232	165	25	9	666	152	2573	2070	12347	8007
2014	4057	967	4383	4184	540	330	474	266	1974	97	455	111	3504	1911	15387	7866
2015	2941	610	4450	3583	415	220	219	47	1775	650	425	169	313	83	10538	5362
2016	2515	852	5150	4189	515	628	1019	106	25	230	199	157	2631	979	12054	7141
2017	1484	511	5197	2148	1,138	353	565	257	575	52	195	173	386	47	9540	3541
Max	4057	1258	5197	4209	2764	801	1199	266	1974	650	666	173	3504	2169	**19361**	**9526**
Avg	2210	830	3598	2643	946	401	439	89	517	140	372	116	1295	777	**9376**	**4996**

1 -- Data from the Service's *Service Permit Issuance and Tracking System* database.

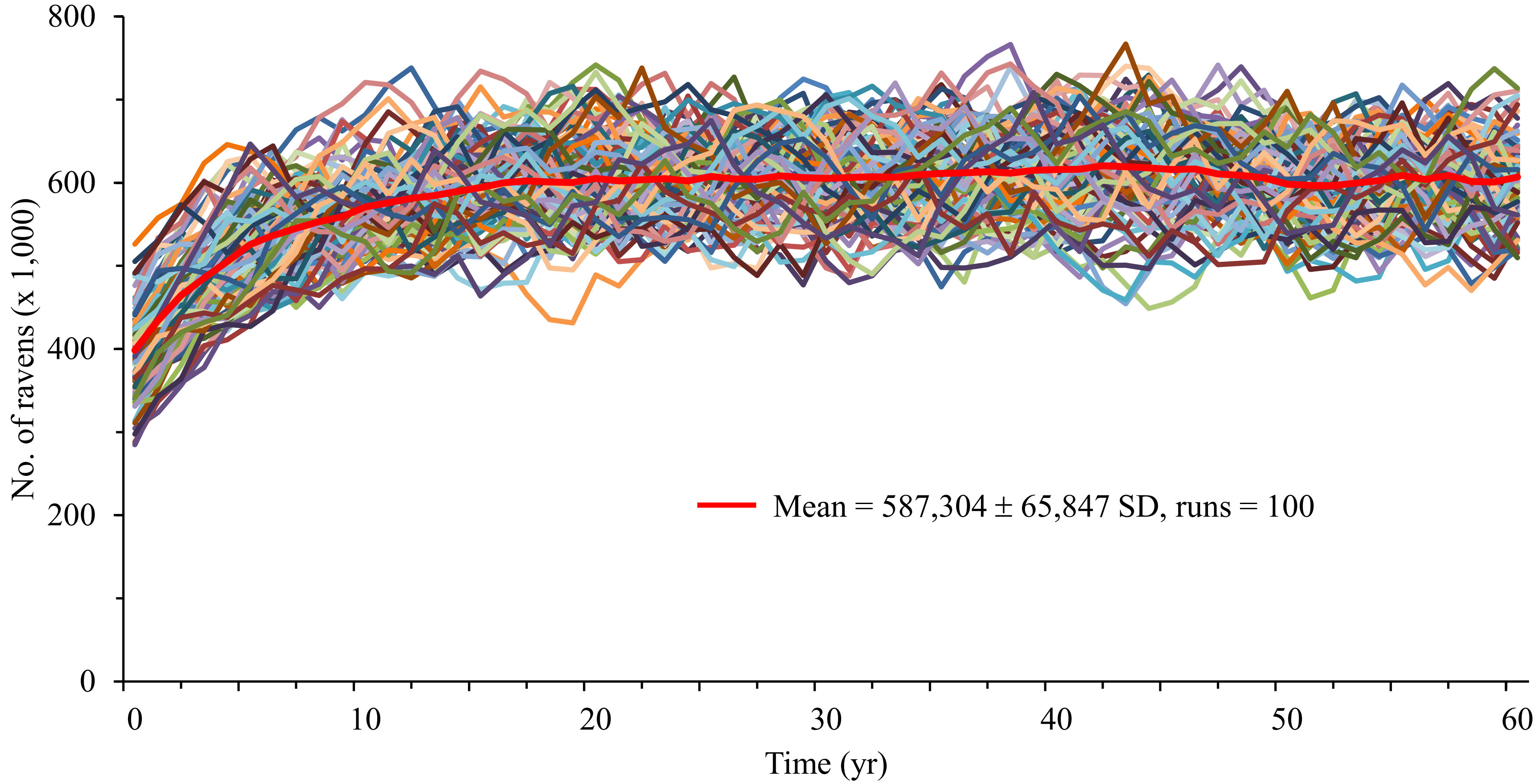

Figure 5: Estimated raven population trend in the Great Basin under any alternative.

As described under Alternative 2, the raven population of the Great Basin is so large, and the growth rate so robust, that any take of adults or nests from the Baker PAC would have an inconsequential effect on the raven population growth rate at the Great Basin scale. The sum of take authorized under any of the alternatives analyzed here, with take potentially authorized across seven western states, will cumulatively have no detrimental effect on the long-term viability of ravens in the Great Basin. In contrast, we expect raven populations to continue to grow coincident with the expanding human population in the west, as it has over the last 50 years, without other large-scale concerted efforts to reduce human subsidies, raven populations, or both.

The non-lethal raven management activities would occur in the Cow Lakes PAC under this alternatives and the effects to ravens in the Cow Lakes PAC will be as described above under the Alternative 1.

9.5.2 Effects on Sage-grouse

The effects on sage-grouse under Scenario 1 would be the same as described under Alternative 2 – Nest Take Only.

Under Scenario 2, recall that nest removal occurs in years 1 and 2 and adult take would potentially occur in two subsequent years of the study. Nest removal would have similar impacts on sage-grouse to those described under Alternative 2 (i.e. presumably of some benefit to sage-grouse as raven depredation on sage-grouse nests would be lessened) plus the effects of removal of adult ravens which would presumably reduce the density of adult ravens to the target density of 0.15 ravens/km^2. Research elsewhere has shown that this raven density reduces predation on sage-grouse to the extent that sage-grouse productivity improves and leads to higher survival and recovery of sage-grouse populations (see Section 7.2). Thus, the overall effect on sage-grouse in the Baker PAC under these scenarios is likely to be positive.

As noted above, this research project is occurring in the context of a large targeted restoration effort to enhance and restore sage-grouse habitat and population in the Baker PAC. If raven nest destruction induces a shift in raven foraging behavior, or adult removal reduces raven densities, these actions could confer immediate relief from raven-caused depredation of sage-grouse nests and halt further sage-grouse declines while habitat restoration and raven subsidy removal activities have time to take effect. If ravens do not respond as predicted, they could continue to exert heavy predation pressure on sage-grouse, preventing their recovery in the Baker PAC. Raven depredation pressure might be so severe as to cause the eventual extirpation of sage-grouse from this PAC. If ravens have no effect on sage-grouse populations then this Service decision would not influence the negative population trend in the Baker PAC.

Effects to sage-grouse in the Cow Lakes PAC would be as described above under other alternatives.

9.5.3 Effects on Non-Target Migratory Birds

9.5.3.1 Black-billed Magpie

Like ravens, magpies are omnivorous, opportunistic, and their diet includes eggs (Hall 1994). As such, and because it is a corvid (see Section 5.2.2), magpies might be exposed to DRC-1339-laced eggs during the course of this experiment. Precautions will be taken to expressly limit their exposure (see Section 5.2.2), but some individual birds might be incidentally killed.

The estimated population of black-billed magpie in the combined BCR 9 and 10 (which corresponds to the Great Basin) is 1.8 million birds (Partners in Flight Science Committee 2020). Their population trends are increasing in BCR 10, and across BBS routes in the Western United States (although not statistically significant; Sauer et al. 2017). In BCR 9, 50-year and 10-year population trends indicate a statistically non-significant decline (Sauer et al. 2017). The species is common throughout eastern Oregon with statewide population estimates at 140,000 (Partners in Flight Science Committee 2020), and data indicate an increasing, statistically non-significant trend in Oregon (Sauer et al. 2017).

With the abundance and generally increasing trends at larger scales described above, any incidental take of magpies is not expected to be measurable either within the Baker PAC area or across the Great Basin. Therefore, the incidental take of magpies associated with the proposed permit issuance is not significant.

If ravens populations decrease as a result of this alternative, it is possible that magpies will experience the same release from predation pressure as sage-grouse. And, as described under Alternative 2, it is possible that magpies in the Baker PAC area might increase modestly as they experience decreased competition from ravens for food resources.

Effects on magpies in the Cow Lakes PAC under this alternative will be as described under Alternative 1 (Section 8.3).

9.5.3.2 American Crow

Like ravens, crows are highly intelligent and omnivorous, and also eat eggs (Johnson 1994). As with magpies, crows might be exposed to DRC-1339-laced eggs during the course of this experiment. The same precautions will be taken to limit crow and magpie exposure (see Section 5.2.2), but some individual birds might be incidentally killed.

Crows are ubiquitous in the U.S. with an estimated population of 17 million individuals (Partners in Flight Science Committee 2020). In combined BCRs 9 and 10, there are an estimated 1.3 million crows (Partners in Flight Science Committee 2020).

Population trends, however, are showing a mixture of non-significant and significant declines broadly in BCRs 9 and 10, and generally across the Western U.S. BBS routes (Sauer et al. 2017). In some regions the negative trend is steeper over the most recent decade of analysis than the 50-yr trend (BCR 9 trends: 1966-2015: - 0.44 ± 0.48% per year; 2005-2015: -1.19 ± 1.48% per year; Sauer et al. 2017). The species is common throughout Oregon with statewide population estimates at 190,000 (Partners in Flight Science Committee 2020). In contrast to recent trends across BCRs 9 and 10, BBS data indicate increasing populations within Oregon, though these trends are not statistically significant (1966- 2015: 0.24 ± 0.53% per year; 2005-2015: 0.12 ± 1.44% per year; Sauer et al. 2017).

Thus, with crows being abundant and increasing statewide, any incidental take that might occur because of this experiment is expected to be undetectable from a population perspective within the Baker PAC and within the Great Basin.

As described for sage-grouse and magpies, crows might increase in the Baker PAC area as they might also experience a release from predation pressure and decreased competition for food from ravens.

Effects on crows in the Cow Lakes PAC under this alternative will be as described under Alternative 1 (Section 8.3).

9.5.3.3 Other Corvids

Most members of the Family Corvidae (or ‘corvids’, including ravens, crows, jays, nutcrackers) prey on eggs of other birds (Jones and Hungerford 1972, Sieving and Willson 1999, Trost 1999, Verbeek and Caffrey 2002, Coates et al. 2008, Howe and Coates 2014) although the extent to which they may eat larger eggs such as poultry eggs (used to deliver DRC-1339) varies by species. They also tend to be more sensitive to DRC-1339 than other species of birds (see Section 3.4.1.). Corvids which co-occur with sage-grouse habitat in the Baker PAC include common raven, American crow (*Corvus brachyrhynchos*), and black-billed magpie (*Pica hudsonia*). Other corvids occur in Baker County, but are unlikely to be found in sage-grouse habitat due to the lack of tree cover. For instance, Clark’s nutcracker (*Nucifraga columbiana*) is associated with subalpine forests, Steller’s jay (*Cyanocitta stelleri*) occurs primarily in evergreen forests, and Canada jay (*Perisoreus canadensis*) occur in evergreen (especially spruce) and mixed evergreen-deciduous forests. Pinyon jays (*Gymnorhinus cyanocephalus*) live in pinyon and juniper woodlands and will not be exposed to these baits. These species have never been documented on the single Breeding Bird Survey route located within the Baker PAC (‘Sparta’ route # 6938; Pardieck et al. 2017). Furthermore, nearly all occurrence records for these species in Baker County are in forested or mountainous habitat, not in sagebrush (ebird Northwest 2020), and thus they are not analyzed here.

9.5.3.4 Effects to Raptors and Other Scavengers

DRC-1339 is considered to be highly selective because (1) the delivery method can be targeted to avian species that consume eggs (e.g. corvids) and (2) the lethal dose (LD50) for corvids is ≤10 times that of most raptors and mammals. It is highly unlikely that use of DRC-1339 would result in death of raptors and scavengers of dead ravens because of the product’s relatively low toxicity to species that might scavenge on birds killed by DRC-1339, and because of the tendency for DRC-1339 to be rapidly and almost completely metabolized in the target birds (Cunningham et al. 1979). Most DRC- 1339 is metabolized upon ingestion and only minimal residual amounts of unmetabolized DRC-1339 typically remain in the target’s carcass;, the residual is typically below toxic levels to avian and mammalian scavengers (DeCino et al. 1966, Cunningham et al. 1979, Schafer Jr 1981, Eisemann et al. 2003). Laboratory research and field trials have shown that lethal secondary exposure of non-target species through consumption of raven carcasses is highly unlikely (DeCino et al. 1966, Besser et al. 1967, Ford 1967, Royall Jr et al. 1967, Cunningham et al. 1979).

It is unlikely that ground squirrels that consume egg baits are affected by DRC-1339 as the lethal dose (LD50) for similar sized small mammals is very high (Ford 1967, Sterner et al. 1992). In fact, the amount needed to kill a fasted female albino rat is 1170 mg/kg (Ford 1967); using this as a proxy, an average-sized ground squirrel (0.33 kg) would need to consume 386 mg of DRC-1339, the equivalent of nearly 200 eggs (each baited egg contains approximately 2 g of chemical; Coates 2007).

No additional indirect effects are anticipated for non-target species, and no significant effects are anticipated.

9.5.3.5 Effects to Sagebrush-Obligate Songbirds

Under this alternative, other species of birds, mammals, and other taxa that live in sagebrush habitats and would otherwise be prey for ravens, would benefit from changes in raven foraging behavior due to nest removal, and from direct reductions in the adult raven population in the Baker PAC, as well as from subsidy removals in the Cow Lakes PAC. The degree to which they might benefit is not known. Exposure of songbirds to the avicide is extremely unlikely; generally speaking, these species are not egg predators, and are not seen at egg-bait locations.

It is possible that other nest predators, e.g. magpies and crows, might increase as a result of raven nest removal or adult raven take. In this case, nest predation by these other species might increase, offsetting any reductions due to raven removal.

In the Cow Lakes PAC, effects to these species under this alternative will be as described under Alternative 1 (Section 8.3).

9.5.4 ESA-Listed Species

There are no species listed under the Endangered Species Act, or designated critical habitats, which occur in the Baker or Cow Lakes PACs, thus there will be no effect of the proposed action on ESA-listed species or designated critical habitats.

9.5.5 Effects on Other Species

As described for Alternative 2, other scavengers or birds that use perching or nesting structures similar to ravens may be affected by the removal of subsidies in the Cow Lakes PAC. Like ravens, these species might experience greater competition for food and/or nesting substrates and might disperse elsewhere or experience localized population declines.

9.5.6 Other Effects

Other effects resulting from Alternative 3 are similar to those described for Alternative 2. Some segments of the public may oppose the proposed action because they may find destruction of raven nests, eggs, or adult ravens to be unacceptable even if raven populations at both the Baker PAC and at larger scales will continue to thrive despite implementation of this alternative. It is the obligation of the Service to comply with its legal authorities to consider permit applications in light of population-level consequences on the species being taken. In addition, however, the value of the proposed study is in the potential beneficial consequences for a species, sage-grouse, that might be declining in the Baker PAC in part due to high raven densities.

9.6 Alternative 4: Issue Permit for Adult Take Only

Under this alternative, the Service would issue a scientific collecting permit authorizing the take of adult ravens only to reduce raven density and relieve sage-grouse from nest depredation by ravens. This alternative differs from ODFW's request because it does not allow for the take of nests as a first step to change raven foraging behavior. Instead, this alternative would authorize the removal of up to 400 adult ravens per year for up to three years beginning in the first year of study; 1,200 adults could potentially be taken under this alternative. However, the intent would be to remove only as many adult ravens as would be necessary to achieve the target density of 0.15 ravens/km^2, leaving roughly 200 adults in the Baker PAC at all times. DRC-1339 would be the method used to take adults, as described in Alternative 3. As described in other alternatives, a separate take permit (either a Depredation or Scientific Collecting Permit) would be required should ODFW propose to resume lethal removal of ravens after their study has concluded, prompting subsequent NEPA review.

9.6.1 Effects on Raven Populations

Raven population modeling indicated that in year 5, after three years of raven removal in the Baker PAC (up to 400 ravens/year) would reduce the number of adult ravens to 144 ± 80 (± 95% CI) and a density of about 0.11 ravens/km^2, yet the number of nests would be expected to remain at 74 ± 2 (± 95% CI) (Table 1). After 15 years, assuming no immigration, we estimate the raven population would be rebound to 692 ± 362 (± 95% CI) (Table 1) ravens.

The effect to ravens at the scale of the Great Basin were described in Alternative 3 (Section 8.5.1.2), and the same result would apply to ravens in the Cow Lakes PAC as described in previous alternatives.

9.6.2 Effects on Sage-grouse

As described under Alternatives 2 and 3, we expect that the effects to sage-grouse from raven removal would be increased productivity, higher brood survival, and in years 3 and 4, higher numbers of males attending leks in the Baker PAC. The overall effect on sage-grouse in the Baker PAC under this alternative is likely to be positive.

Effects to sage-grouse in the Cow Lakes PAC would be as described above under other alternatives.

9.6.3 Effects to Corvids, Raptors, and Scavengers

We described the potential effects of using DRC-1339 to American crows, black-billed magpies, raptors, and scavengers in Section 5.2.2. The effects to these species, incidentally taken under Alternative 4, would be potentially slightly higher than under Alternative 3 since adult take could be implemented for three years instead of two. Nonetheless, because of the precautions used during baiting, the incidental take of non-target birds and mammals is expected to be small and not significant.

9.6.4 Effects on Other Species

The effects to other species of birds (e.g. sagebrush-obligate species such as Brewer's sparrow and green-tailed towhees), and to mammals and endangered and threatened species, would be similar to that described above, Sections 8.5.3.5, 8.5.4, and 8.5.5. That is, with raven populations reduced in both the Baker and Cow Lakes PACs, species that might otherwise fall prey to raven depredations might achieve higher rates of nest success and survival. Because non-lethal management would occur in the Cow Lakes PAC under Alternative 4, other species dependent on human subsidies would experience similar impacts to those described in the previous alternatives.

9.6.5 Other Effects

Other effects resulting from Alternative 4 are similar to those described for Alternative 2. However, there might be even greater opposition to this alternative because more ravens could be killed if it were chosen. Others, however, might recommend this alternative over alternatives 1, 2, and 3 because adult raven take alone, where it has been tried in other locations, has yielded positive responses in local sage-grouse population trends (see Section 7.2).

10 List of Agencies and Persons Consulted

In developing this document we consulted Oregon Department of Fish and Wildlife, Oregon State University, and the Bureau of Land Management.

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Appendix A: Oregon Department of Fish and Wildlife Study Design

SECTION (i)

Greater sage-grouse (*Centrocercus urophasianus*; hereafter "sage-grouse") distribution and abundance in western North America has declined over the past century (Schroeder et al. 2004, Connelly et al. 2011, Garton et al. 2011, Nielson et al. 2015), which has prompted multiple petitions to the U.S. Fish and Wildlife Service (USFWS) to list sage-grouse as Threatened or Endangered under the Endangered Species Act (U.S. Fish and Wildlife Service 2015). In Oregon, sage-grouse populations have declined concurrently with populations throughout the range of their distribution (Garton et al. 2011, Nielson et al. 2015). Sage-grouse breeding populations are now confined to six Oregon counties, largely within 20 mapped areas of high population density, known as Priority Areas for Conservation (PACs; SageCon 2015). Population trajectory within these PACs is variable; however, populations have declined alarmingly within the Baker PAC, in Baker County, on the northeastern edge of sage-grouse range in Oregon. This population is estimated to have declined by 75% since 2005, with only 494 estimated individuals remaining in 2020 (Oregon Department of Fish and Wildlife [ODFW], *unpublished data*).

Multiple factors influence productivity of sage-grouse, including the quantity and condition of habitat, the level of anthropogenic disturbance in an area, weather, and predation (Connelly et al. 2011). Ground nesting birds, such as sage-grouse, are susceptible to increasing densities of generalist predators, such as common ravens (*Corvus corax*; hereafter "ravens"; Bui et al. 2010, Coates and Delehanty 2010, Lockyer et al. 2013, Dinkins et al. 2016a, Peebles et al. 2017, Coates et al. 2020). Researchers have found sage-grouse minimize predation risk both directly, by avoiding avian predators (e.g., corvids [*Corvus* spp.], *Buteo* hawks [*Buteo* spp.], golden eagles [*Aquila chrysaetos*], and northern harriers [*Circus hudsonius*]), and indirectly, by avoiding habitats with high predator density (Dinkins et al. 2012, Dinkins et al. 2014). These combined effects of avian predators on sage-grouse habitat use and nest-success may have considerable implications for sage-grouse population persistence into the future.

Raven abundance has increased throughout the western United States over the past several decades (Sauer et al. 2017) mostly attributed to human activity, which subsidizes raven populations through increased food resources (e.g., road kill, dead livestock, etc.) and availability of perch and nesting structures (buildings, powerlines; Boarman 1999, Coates et al. 2014, Howe et al. 2014). Recent research has found moderate to high raven densities in sage-grouse habitat led to lower sage-grouse nest success and resulted in lower in population size (Coates and Delehanty 2010, Dinkins et al. 2016a, Peebles et al. 2017, Coates et al. 2020). Research from Coates and Delehanty (2010) estimated 7.3 ravens observed per 10 km transect, or 0.45 ravens/km^2, as the threshold where sage-grouse productivity falls below that required for population persistence. Additionally, Coates et al. (2020) found sage-grouse nest success in the Great Basin rapidly declined at raven densities higher than 0.20 ravens/km^2, and nest success was well below average at densities above 0.40 ravens/ km^2 (this study was inclusive of data from the Baker PAC). Finally, several studies have suggested raven densities as low as 0.20 ravens/km^2 contribute to lower sage-grouse nest success (Bui et al. 2010, Dinkins 2013, Dinkins et al. 2016a, Coates et al. 2020). Decreases in sage-grouse lek counts were also observed in areas with raven densities above 0.20 ravens/km^2 in Wyoming (Peebles et al. 2017).

Nesting adult ravens have relatively small home ranges where they intensively forage to meet the increased energetic demands associated with rearing young (Bui et al. 2010, Harju et al. 2018, Boarman and Heinrich 2020). Due to this focused foraging behavior, breeding adult ravens may have a much greater impact on sage-grouse, in regard to nest predation, than non-breeding ravens (Harju et al. 2018). Researchers studying the effects of nest failure on raven behavior and movement during the breeding season have suggested lethal removal of raven nests may benefit local sage-grouse populations by lowering nest predation and directly improving sage-grouse nesting success (HWA Wildlife Consulting 2017, Harju et al. 2018). Following nest failure, breeding ravens often revert to non-breeding behavior and increase foraging distances to utilize subsidized food sources (e.g., landfills, roadkill, transfer stations, etc.; Harju et al. 2018). Lethal take of raven nests in sage-grouse habitat has resulted in ravens modifying their behavior post-treatment, where breeding adults increased movement distances following nest loss (HWA Wildlife Consulting 2017). Similarly, take of adult ravens within sage-grouse nest habitat resulted in increased sage-grouse nest success (Coates 2007, Dinkins et al. 2016a). A study implementing lethal removal of ravens observed a doubling in sage-grouse nest success in their study areas after raven densities were reduced from 0.40–0.45 ravens/km^2 to ~0.25 ravens/km^2 (Dinkins et al. 2016a).

Oregon, including the Baker PAC area, indicated a raven density of 0.89 (95% CI: 0.596 – 1.32) ravens/km^2 (Coates et al. 2020); this density is greater than the sage-grouse population persistence threshold identified by Coates and Delehanty (2010) and Dinkins et al. (2016a). Additional data collected within sage-grouse nesting habitat in the Baker PAC during 2017-19 indicated a density estimate of 0.44 (95% CI: 0.32 – 0.60) ravens/km^2 (J.B. Dinkins, pers. comm). While considerably different, these two estimates give us a range of potential densities with which to evaluate the effect of raven nest and adult removal experiments on raven predation on sage-grouse in the Baker PAC. Additionally, both density estimates are above the threshold (≤0.4 ravens/km2) for effects on sage-grouse found elsewhere across the west (Coates et al. 2020). We use the lower density (0.44 ravens/km^2) to estimate the population of ravens in the Baker PAC and the short-term effect of raven removal on raven density in the Baker PAC. Using the lower density estimate will be a more conservative approach to evaluate the effect of raven removal on the raven population within the Baker PAC, where using the higher density estimate might result in false success of the raven removal. Assuming a population density of

0.44 ravens/km^2, we estimate the raven population in the Baker PAC to be about 600 ravens in this 1,361 km^2 area.

In addition to the Baker PAC, the Cow Lakes PAC (Malheur County, OR) has anecdotally high raven numbers, and sage-grouse lek trends have also declined. Sage-grouse population trends and habitat loss within both of these PAC's have tripped adaptive management triggers under the Bureau of Land Management (BLM) Approved Resource Management Plan (ARMPA; BLM 2015). To mitigate the negative effects of high raven density on sage-grouse, lethal raven manipulation (either destruction of nests or take of adults) will be implemented in the Baker PAC, and non-lethal raven manipulation will be implemented in the Cow Lakes PAC (specific management actions described below). Data collected by the Dinkins Lab at Oregon State University (OSU) will inform ODFW during selection of areas to implement targeted lethal and non-lethal raven manipulation techniques. Specifically, habitat use and demographic rates obtained from GPS-marked ravens will be used to determine appropriate methods to use to limit the negative impacts of raven predation on sage-grouse populations. OSU will evaluate the effectiveness of these management actions by comparing sage-grouse reproductive success at lethal raven management sites (Baker), non-lethal raven manipulation (Cow Lakes), and two reference PACs where no raven management actions specifically for the benefit of sage-grouse will occur (Bully Creek and Soldier Creek; study design and methods described in detail in the Study Proposal section). The reference PACs (Bully Creek and Solider Creek) are within the northern Great Basin and have similar sage-grouse habitat potential as the Baker and Cow Lakes PACs. The study design (Before-After-Control-Impact [BACI]) requires before and after data on sage-grouse habitat use and reproductive success from study areas with management actions while concurrently gathering data at reference study areas to use as relative comparisons (i.e., the reference areas do not need to be identical to the treatment areas, but they need to be free of other large-scale changes that could influence interpretations). These reference PACs do not currently have any new large-scale habitat changes. Thus, the goals of this study are to 1) evaluate the habitat use, demographic response, and population response of sage-grouse to lethal and non-lethal raven management techniques, and 2) evaluate the habitat use and demographic patterns of ravens in study areas both preceding and following lethal and non-lethal raven management techniques).

Survey data from 2016 indicated raven density in the Baker PAC was at a level with high potential to limit sage-grouse productivity. ODFW has proposed a 4-year experiment, to adaptively manage ravens to reduce sage-grouse nest predation and increase sage-grouse nest success in the Baker PAC. Due to the untested efficacy of reducing raven populations with non-lethal means and the potential long timeframes required with these techniques, lethal raven removal will be necessary to achieve the goals of this project in the Baker PAC. To address this knowledge gap, non-lethal raven management will be conducted in the Cow Lakes PAC as the first large scale test of these techniques to reduce raven impacts on sage-grouse and will be informed by raven data currently being collected by OSU. These non-lethal techniques will include removal of roadkill and agricultural food resources and reducing the ability of ravens to nest on powerlines and other human infrastructure. Lethal removal locations in the Baker PAC will be identified through location data obtained from GPS-collared ravens (see Study Proposal, below), direct observation of raven nests, and foraging behavior of ravens in order to target that portion of the raven population foraging in sagebrush dominated landscapes and thus, most likely to be responsible for sage-grouse nest predation events.

The adaptive management strategy, which is described below and outlined in Figure 1, establishes criteria which will be used to assess the effectiveness of the lethal treatment. Based on these criteria (i.e. effective, ineffective, or inconclusive), management actions will either remain the same for the following year, or be modified to align with the strategy and achieve the goal of improving sage-grouse nest success in the Baker PAC. The first proposed action is the take of ≤ 100 raven nests annually within the Baker PAC. Raven territory size ranges from 5.07 – 36.32 km^2 (Boarman and Heinrich 2020), which would equate to 37 – 268 potential territories within the Baker PAC (1,361 km^2). However, average distance between raven nests in sage-grouse habitat is approximately 5.0 km (Howe et al. 2014), which would equate to 70 potential territories within the Baker PAC, and based on preliminary survey data collected during the 2018 breeding season, the Baker PAC has a raven nest density of approximately 0.035 nests per km^2. In 2018, approximately 649 km^2 were searched and 23 raven nests were documented. This accounts for about 48% of the entire PAC and 71% of the PAC available for survey (access was not possible on some private lands). However, this estimate does not account for imperfect detection of nests during surveys or re-nesting rate and is biased toward nests on public lands. Based on average territory sizes reported in the literature, our preliminary survey data, and accounting for re-nesting following nest loss, we propose take of ≤ 100 nests annually to reduce the impact of raven predation on sage-grouse nests and improve sage-grouse nesting success. Take of raven nests would occur as manual destruction of nests and raven eggs. Raven nests will be taken prior to hatch to avoid killing hatchlings in the nests. If manual destruction of nests does not deter ravens from nesting at the site and re-nesting following destruction occurs frequently, egg oiling will be used following the first nesting attempt. Coating the raven eggs with food-grade corn oil will stop air exchange through the eggshell and prevent hatching. If nest destruction (manual or oiling) proves ineffective, the second proposed action is the removal of ≤ 400 ravens from the Baker PAC, reducing the estimated population from ~600 to ~200 individuals. This reduction will maintain raven density within the Baker PAC at approximately 0.15 raven/km^2, which is below the threshold where sage-grouse nest success begins to decrease (0.20 ravens/km^2; Coates and Delehanty 2010, Dinkins et al. 2016, Coates et al. 2020). Take of adult ravens would be implemented through the application of DRC-1339 by ODFW or their licensed agents. If DRC-1339 is used, any raven carcasses recovered following the application of the toxicant will be destroyed.

Adaptive management strategy (Figure 1.) – During the first and second years of the study, ODFW proposes take of ≤ 100 raven nests located within in the Baker PAC annually.

Following the analysis of these first two years of data:

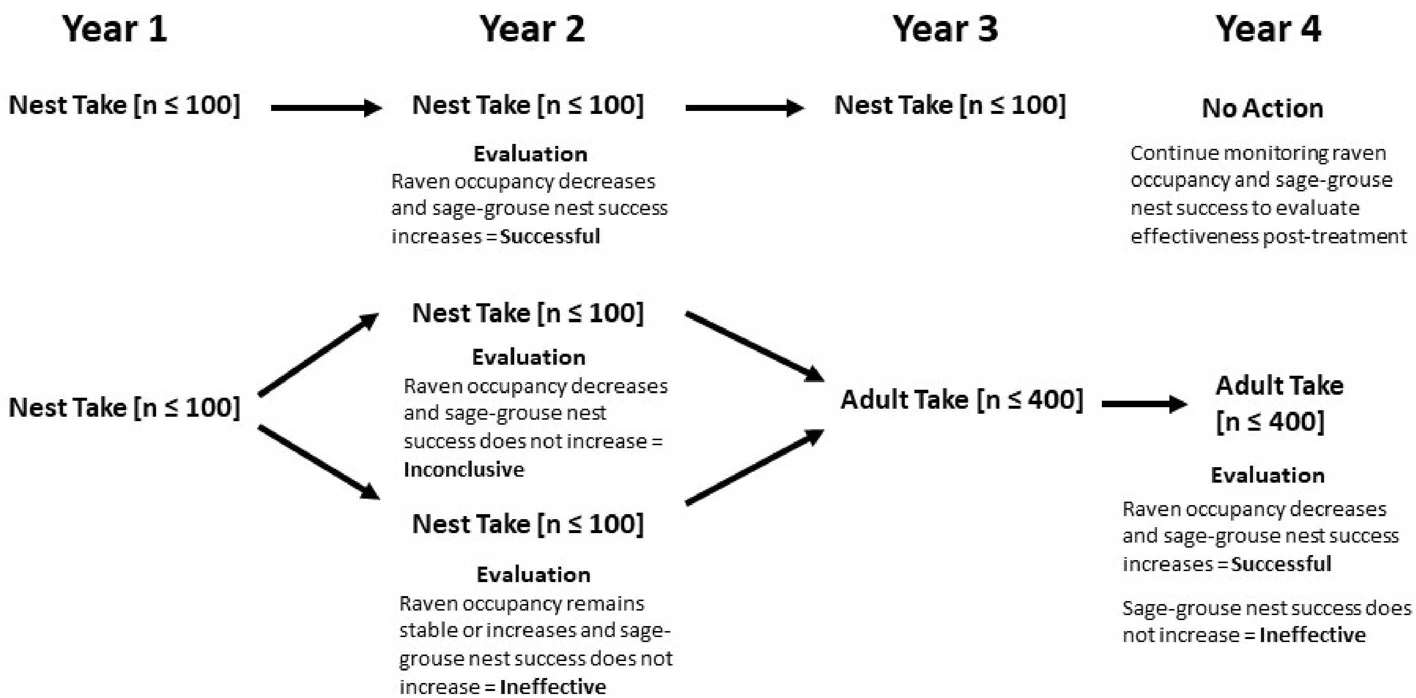
- If raven occupancy in sage-grouse habitat during nesting season within the treatment area decreases and sage-grouse nest success increases, nest take will be considered **successful**.
- If raven occupancy remains stable or increases and sage-grouse nest success does not improve, nest take will be considered **ineffective**.
- If raven occupancy decreases and sage-grouse nest success does not increase, nest take will be considered **inconclusive**.

If nest take is deemed successful following the second year, this will result in the take of ≤ 100 raven nests during the third year of the study and take of adult ravens will not be implemented. If nest take was deemed ineffective or inconclusive after two years, take of ≤ 400 adults will be implemented during the third and fourth years of the study. In this scenario, the number of adult ravens taken will be informed by raven density estimates from point counts conducted prior to raven removal. This will ensure the target density of 0.15 ravens/km^2 is met. Potentially suppressed raven densities from the previous year's take will likely result in fewer than 400 ravens taken during the fourth year.

For non-lethal management, management agencies and OSU will have one management strategy to attempt to remove all roadkill and agriculture (dead livestock) food subsidies at least bi-weekly (weekly, if possible) in the areas of the Cow Lakes PAC that are accessible. The goal will be to eliminate raven access to large food subsidies. Management agencies and OSU will also identify powerlines and other human infrastructure with new construction of raven nests (prior to egg laying) to remove nesting material and make those structures inaccessible to ravens for nesting.

This research project is occurring in the context of a large, targeted restoration effort to enhance and restore the sage-grouse population and habitat quality in the Baker PAC. See attached for a complete draft of the Baker PAC Comprehensive Threat Reduction Plan, of which raven removal and research is only a small part.

Figure A-1. Flowchart outlining the adaptive management strategy proposed by ODFW for take of raven nests or adults.



Oregon State University Study Proposal

PROJECT DESCRIPTION

Sage-grouse distribution and abundance in western North America has declined over the last century (Schroeder et al. 2004, Connelly et al. 2011, Garton et al. 2011, Nielson et al. 2015), which has prompted multiple petitions to the U.S. Fish and Wildlife Service (USFWS) to list sage-grouse as Threatened or Endangered (U.S. Fish and Wildlife Service 2015). Many factors have been attributed to this decline including habitat fragmentation, habitat loss, and predation (Connelly et al. 2011). Several studies suggest that quantity and condition of breeding habitat (micro and landscape scale habitat) dictate the productivity of sage-grouse (Connelly et al. 2011, Connelly et al. 1994, Gregg and Crawford 2009, Kirol et al. 2015, Doherty et al. 2016). Herbaceous cover is important to conceal sage-grouse nests from predators (Coates and Delehanty 2010, Dinkins et al. 2016a, Gregg et al. 1994) and microhabitat characteristics such as sagebrush (*Artemisia* spp.) cover and grass height can influence predation rates at sage-grouse nests (Coates and Delehanty 2010, Doherty et al. 2014, Kirol et al. 2015, Dinkins et al. 2016b). Habitat quality, including concealment cover, also influences brood survival (Gregg and Crawford 2009, Guttery et al. 2013, Kirol et al. 2015, Dalhgren et al. 2016). Landscape factors, such as juniper encroachment, annual grasses, and fire, have negative consequences on sage-grouse population growth (Baruch-Mordo et al. 2013, Knick et al. 2013, Coates et al. 2016, Doherty et al. 2016). Understanding mechanisms influencing sage-grouse habitat use and demographic rates related to habitat quantity and quality, including interactions among habitat and predators, are essential to ensure long-term effective conservation and restoration success.

Even in excellent sage-grouse habitat, most sage-grouse failed nests are lost to predators (red fox [*Vulpes vulpes*], American badgers [*Taxidea taxus*], coyotes [*Canis latrans*], black-billed magpies [*Pica hudsonia*; hereafter "magpies"], and ravens; Willis et al. 1993, Gregg et al. 1994, Heath et al. 1997, Connelly et al. 2011, Coates and Delehanty 2010, Lockyer et al. 2013). Breeding success and population growth of ground-nesting birds can be suppressed by generalist predators, such as ravens (Schroeder and Baydack 2001). Generalist predator abundance is not limited by the density of a particular prey species, and generalist predators often capitalize on human provided resources (Schroeder and Baydack 2001, Evans 2004, Manzer and Hannon 2005). Raven presence and higher densities have been consistently associated with decreased sage-grouse nest success (Bui et al. 2010, Coates and Delehanty 2010, Dinkins et al. 2016a, Coates et al. 2020) and lek trends (Peebles et al. 2017). Loss and degradation of concealment cover (e.g., sagebrush cover and grass height) combined with increasing raven abundance may interactively reduce sage-grouse nest success. For example, sage-grouse nests with greater sagebrush cover were less likely to be depredated by a raven (Coates and Delehanty 2010).

Raven abundance has increased throughout the western United States (Sauer et al. 2017), and ravens can reach high densities in landscapes with human-subsidized resources by utilizing human-provided food resources (road-kill, dead livestock, and garbage), perch structures (buildings, power lines, oil and gas wells, etc.), and overwintering shelter (industrial facilities; Boarman et al. 1995, Boarman 1999, Coates et al. 2014, Howe et al. 2014). Sources of perch and nesting structure attract ravens and may increase their foraging ability. In addition, nesting ravens have relatively small home ranges where they intensively forage to meet the increased energetic demands associated with rearing young (Bui et al. 2010, Harju et al. 2018, Boarman and Heinrich 2020). Ravens have greater use of areas where intact sagebrush habitat adjoins disturbed habitat (Howe et al. 2014). Sage-grouse minimize the risk of predation indirectly by avoiding risky habitat and directly by avoiding avian predators (magpies, Buteo hawks, ravens, golden eagles, and northern harriers; Dinkins et al. 2012, Dinkins et al. 2014). Combined effects of avoidance of suitable sagebrush habitat with high raven abundance, raven presence negatively influencing sage-grouse nest success, and increasing raven abundance in sagebrush habitats may have considerable implications for sage-grouse population growth in the future. These findings suggest increases in raven abundance along with habitat degradation—in the form of anthropogenic features, juniper encroachment, annual grass invasion, and fire—may interactively reduce nest success and use of functional habitat available to sage-grouse.

Unlike other population limiting factors (e.g., weather and drought), predation can realistically and quickly be reduced by wildlife management agencies (Cote and Sutherland 1997, Dinkins et al. 2016a). For example, lethal raven removal by Wildlife Services has been demonstrated as a potential tool to reduce negative impacts of raven depredation on sage-grouse nests (Dinkins et al. 2016a). However, it may be difficult to sustainably implement raven removal for the benefit of sage-grouse across large spatial scales, and long-term solutions to reduce raven impacts on sage-grouse are necessary—such as reducing food subsidies and overwinter shelter for ravens while improving sage-grouse habitat. Another approach to reduce raven depredation of sage-grouse nests would be to discourage them from nesting near sage-grouse nesting habitat, which would minimize raven foraging in areas with sage-grouse nests. Sage-grouse populations in severe decline will likely benefit from raven removal in conjunction with long-term habitat improvement projects, and anthropogenic subsidy removal to maintain low raven abundance.

The sage-grouse population within the Baker PAC has been in severe decline with approximately 494 birds remaining as of spring 2020, and ODFW has quantified high densities of ravens throughout this sage-grouse population (see Coates et al. 2020). In addition, the Cow Lakes and Soldier Creek PACs have exhibited declines in the number of males per lek complex, and the populations in the Baker and Cow Lakes PACs have declined to a level of concern for federal and state agencies. Cow Lakes and Soldier Creek sage-grouse PACs are within the area surrounding Jordan Valley, Oregon, which has anecdotally observed and estimated high raven numbers (see Coates et al. 2020). We propose to identify areas to implement targeted lethal and non-lethal raven manipulation techniques in collaboration with ODFW and federal agencies. For this study, ODFW or their licensed agents will conduct lethal management of ravens by manually destroying raven nests and/or oiling raven eggs and/or take of adult ravens with DRC-1339 or to reduce intense raven foraging in sage-grouse nesting habitat. We plan to identify and implement non-lethal raven manipulation techniques for the benefit of sage-grouse in the Cow Lakes PAC, such as excluding ravens from nesting on powerlines and other human structures, removal of roadkill, and removal of agricultural food resources. We will then compare the efficacy of non-lethal raven manipulation techniques near the Cow Lakes PAC to the removal of nests and lethal removal of adult ravens in the Baker PAC as conservation management strategies to improve sage-grouse demographic rates. We will compare sage-grouse habitat use, nest success, chick survival, and population growth among years before and after raven management. Additionally, we will compare raven densities at the PAC scale as well as occupancy of raven nesting territories within proximity of sage-grouse nesting habitat. This project will also be focused on identifying habitat characteristics associated with high densities of ravens, raven habitat use (movement, foraging habitat, and nest-sites), and raven demographic rates (fledging success and adult survival), which will inform and improve efficacy of non-lethal raven management techniques. As secondary objectives, we will evaluate the influence of annual grass and fire on ravens and sage-grouse in the Baker sage-grouse population and the Bully Creek, Cow Lakes, and Soldier Creek sage-grouse PACs in Oregon.

OBJECTIVES

1) Evaluate interactive effects of ravens (presence and/or abundance) with anthropogenic subsidies, annual grass, and fire on sage-grouse.

2) Evaluate differences in sage-grouse habitat use, nest success, and chick survival in areas with proportionally more annual grass and/or burned area.

3) Assess impacts of lethal and non-lethal raven management on nest success, chick survival, and habitat use of sage-grouse.

4) Identify habitat characteristics associated with habitat use, abundance, and nest success of ravens, including anthropogenic subsidies, annual grass, and fire.

5) Assess raven foraging and roosting behavior associated with sagebrush habitat to determine non-lethal raven management techniques.

6) Evaluate impacts of raven management on raven density at the PAC level.

7) Evaluate impacts of raven management on occupancy of raven nesting territories in proximity to sage-grouse nesting habitat.

DELIVERABLES

Two Ph.D. dissertations and multiple peer-reviewed manuscripts will result from this research. Outreach presentations and OSU Extension bulletins will describe relevant information to aid conservation and monitoring activities in the Baker, Bully Creek, Cow Lakes, and Soldier Creek PACs. In addition to addressing the research objectives outlined below, this project will advance understanding of general sage-grouse ecology in four PACs including sage-grouse habitat use, movement, and demographic rates.

STUDY DESIGN

Our study will be stratified by one study area (Baker PAC) planned to have lethal raven management implemented by ODFW or their licensed agents (lethal treatment area), one study area (Cow Lakes PAC) planned to have non-lethal raven management techniques implemented by management agencies and OSU (non-lethal treatment area), and two study areas (Bully Creek and Soldier Creek PACs) without raven management (reference areas) in eastern Oregon. The Baker and Bully Creek PACs will have four years of data collection (2017-2020) while the Cow Lakes and Soldier Creek PACS will have three years (2018-2020) without raven management. This will be followed by implementation of lethal or non-lethal raven management and data collection focused on assessing effectiveness for four years (2021–2024). The Bully Creek and Soldier Creek sage-grouse PACs will not have raven management and will be monitored concurrently. We will coordinate with private landowners and state and federal agencies to collect data on ravens and sage-grouse. This will allow us to compare the relative change in sage-grouse seasonal habitat use, nest success, potentially chick survival, and lek trends before and after lethal and non-lethal management of ravens. In addition, we will evaluate raven habitat use, movement, demographics, and abundance.

Sage-grouse Monitoring

We will maintain a sample of approximately 80 radio-marked sage-grouse females each year of our study. Captures will occur at night using spotlights and hoop-nets during the spring near lek locations and in the fall around roosting sage-grouse locations (Giesen et al. 1982, Wakkinen et al. 1992). We will deploy 20 VHF necklace collars (22 g, RI-2DM, Holohil Systems Ltd., Carp, Ontario, Canada) or rump-mounted GPS transmitters (22 g, ARGOS/GPS Solar PTT-100, Microwave Telemetry Inc., Columbia, MD, USA) in each study area. Rump-mounted GPS transmitters will provide at least 3 locations per day; however, we will not deploy rump-mounted GPS transmitters in the Baker PAC. To gain fine spatial scale data in the Baker PAC, ≥10 of our VHF-collared sage-grouse in the Baker PAC will be fitted with PinPoint-75 Avian GPS store-on-board (SOB; 4.1 g) tags or PinPoint-120 Avian GPS SOB (4.8 g) tags (Lotek Wireless Inc., St. John's, NL A1A 5C6 Canada). These units attach to the back of the VHF collar and provide 2-3 locations per day. Beginning in summer 2019, these PinPoint units have been deployed on VHF-collared sage-grouse in all study areas as the rump-mounted GPS units are phased out of the study. PinPoint units will be recovered after a mortality event or will be switched annually via recapture, whichever occurs first. We will monitor VHF-collared sage-grouse females with ground tracking using radio telemetry receivers and Yagi antennas during April–August and aerial surveys during the remainder of the year. Locations will be recorded bi-weekly via ground tracking and monthly via aerial surveys.

For hens marked only with VHF transmitters, female survival will be recorded with the aid of telemetry signal (mortality switch); VHF transmitters in combination with PinPoint SOB units will allow for more precise date of mortality. For rump-mounted GPS, female survival will be determined via downloaded location data from satellites. Mortality sites will be visited as soon as possible to assess sage-grouse carcasses and potentially identify cause of death (e.g., disease, fence or power line strike, predator, etc.).

Nest locations will be visually documented while ground tracking for VHF collared individuals or via clusters of GPS locations from those birds marked with rump-mounted GPS and PinPoint SOB units. For hens marked without GPS technology, VHF telemetry will be used to visually confirm a hen is nesting on the first visit to a nest location, then all subsequent nest checks will be done via VHF triangulation to reduce observer disturbance. Nests of females marked with rump-mounted GPS transmitters will be confirmed as soon as possible after downloaded GPS data shows nest initiation behavior. We will assess nest fate as successful or unsuccessful nests after a hen has left her nest. A successful nest will be defined as having evidence that at least 1 egg hatched as determined by eggshell membrane condition for most nests. For hens fitted with rump-mounted GPS, nest fate will be confirmed as soon as downloaded data indicates the hen has moved off her nest. For VHF-marked female sage-grouse with a PinPoint SOB unit, nest locations and nest fate will be assessed posthoc for those hens where a nest was not visually located in real-time. This will be done by assessing clusters of GPS data indicating nest initiation, similar to assessing location data obtained from ARGOS satellites for birds with rump-mounted units. A hen will be considered nesting if locations are recorded within 20m of each other for at least 48 hours between 1 April and 15 June. A nest will be considered successful if those locations are recorded for at least 25 days. A nest will be considered failed if locations are recorded for <25 days.

We will assess brood survival every 7-10 days by either visually detecting chicks or observing hen behavior that indicates the presence of chicks (e.g., hesitation to flush, feigning injury, or clucking; Dinkins et al. 2014; Kirol et al. 2015). Brood failure will be determined as 3 consecutive visits without detecting chicks and counting chicks at night 35-days after estimated hatch date (Kirol et al. 2015).

Raven Monitoring

To quantify the relative density of ravens at the PAC level, we will conduct 10-minute point count surveys at random locations and 100–200 m away from sage-grouse locations (non-reproductive female, nest, and brood; see Dinkins et al. [2012] and Dinkins et al. [2014] for more details). Point count surveys at sage-grouse locations will be within a line-of-sight to the actual sage-grouse location. Survey distance away from sage-grouse locations will prevent disturbing sage-grouse females and causing observer instigated predation events. Point counts at random locations will be conducted in all study areas, and we will conduct 3-5 surveys at each random and sage-grouse location 1 May – 15 July (see attached protocol).

We will monitor up to 90 ravens concurrently with GPS-backpacks throughout all study areas, and wing-tag up to 240 total ravens to evaluate raven habitat use, demographic rates, and locate nests. Areas of concentrated use from GPS-marked ravens will be evaluated as potential areas of subsidized resources. For GPS-marked ravens, clusters of GPS locations within 20 m will be used to identify nest locations. In addition, we will conduct nest searches throughout the Baker, Bully Creek, and Cow Lakes PACs and in other study areas as feasible for non-marked ravens nesting in our study areas with the goal of increasing our sample of raven nests.

Occupancy surveys (see attached protocol) will be conducted once per week at each raven nest found active during a breeding season. These surveys will continue, after nest destruction, until the first week of June to observe any re-nesting attempts. If a raven pair is found to be reinitiating a nest, ODFW or their agents will remove the second nest. Harju et al. (2018) observed breeding ravens shifting space use behavior to resemble that of non-breeding ravens once their nest was destroyed. Occupancy surveys will evaluate occupancy of nesting territories pre- and post-removal. Occupancy surveys at reference nests in the Bully Creek PAC area will be conducted and used to compare results from the occupancy surveys following raven nest destruction in the Baker PAC area.

Macro Habitat Assessment

To assess habitat quality, we will evaluate macro habitat variables at sage-grouse (nest and brood) and random locations. Macro habitat scale vegetation (proportion of tree, shrub, grass, etc.) and habitat features (power lines, roads, buildings, etc.) will be quantified with available GIS layers or manually digitized then associated with sage-grouse and random locations throughout each year.

DATA ANALYSIS

Raven Abundance and Occupancy

We will quantify abundance of ravens using distance sampling models implemented in R package 'unmarked' (Royle 2004, Fiske and Chandler 2011) or R package 'Distance' (Miller et al. 2019). Raven pair occupancy in nesting territories within sage-grouse habitat will be analyzed with the 'unmarked' package in R (MacKenzie et al. 2002). The unmarked package has functions for abundance and occupancy models that allow for inclusion of habitat covariates to describe differences in abundance across the landscape while simultaneously using covariates to describe differences in detection probability; whereas, Distance analyzes distance sampling data with the most robust inclusion of detection probability functions. This will allow us to compare the density of ravens before and after raven manipulation and among study areas.

Comparison of Raven and Sage-grouse Demographic Rates, Seasonal Habitat Use, and Movement

COMPARISONS. We will assess adult and nest survival for ravens and adult, nest, and chick survival for sage-grouse. Adult survival will be analyzed with program MARK or Cox proportional hazards models. Seasonal habitat use and movement of raven and female sage-grouse will be assessed using resource selection functions, generalized linear mixed models, and/or step-selection functions. Habitat variables (including proximity and density of trees, burned area, annual grass, etc.) will be used as predictors of raven and female sage-grouse habitat use and movement. In addition to habitat variables, raven abundance will be assessed as interactive effects with habitat variables influencing sage-grouse habitat use, nest success, and brood survival. Interactions among raven abundance and habitat variables will evaluate whether sage-grouse survival rates and seasonal habitat use are disproportionally influenced by the combination of pairs of these variables. To evaluate the long-term influence of ravens on sage-grouse populations and benefits of raven management, sage-grouse lek trends in lethal and non-lethal study areas will be compared to raven abundance across approximately eight years. Raven nesting pair occupancy or time active within sage-grouse nesting habitat will be compared as interactive effects with year (i.e., years before and after treatments) and treatment type (i.e., lethal, non-lethal, and reference study PACs). Raven abundance will be also compared as interactive effects between year and treatment type, which will especially be informative to assess the efficacy of non-lethal management. Comparison of raven density as interactive effects with year and treatment type will also be informative if lethal adult removal occurs. After establishing raven management was effective, we will assess the efficacy of that management to benefit sage-grouse by comparing sage-grouse nest success and habitat use in areas where raven nesting activity or density decreased to areas where it remained stable or increased.

BENEFITS

This research will help inform management decisions on the effectiveness of raven management as a conservation strategy for sage-grouse in the Baker and Cow Lakes PACs, while also thoroughly assessing interactive effects of ravens and habitat conditions on sage-grouse habitat use and demographic rates. Furthermore, raven ecology will be simultaneously studied to identify non-lethal conservation activities to reduce negative effects of ravens on sage-grouse in eastern Oregon. Project effectiveness will be evaluated with annual reports, submission of two PhD dissertations, and publication in peer-reviewed journals and extension bulletins. We expect several peer-reviewed papers and extension bulletins will result from this research. Our study will also provide crucial information on abundance of numerous avian species relative to sage-grouse habitat, habitat condition for sage-grouse, and general sage-grouse ecology. The general public will benefit from this project through improved management of sagebrush ecosystems on public lands by management agencies. This research will also help management agencies improve restoration success of sagebrush habitats for sage-grouse, thereby, reducing the need for listing under the Endangered Species Act.

This study aligns with Task 5.2 of the Oregon Conservation Strategy, and Action PRD-2 of the Oregon Greater Sage-Grouse Action Plan by 1) assessing sage-grouse response to the conservation action of reducing raven density in sage-grouse habitat, 2) filling data gaps associated with sage-grouse habitat use, movement, and demographic rates, and 3) gathering information on sage-grouse responses to annual grass and fire. The Oregon Conservation Strategy refers to the Greater Sage-Grouse Conservation Assessment and Conservation Strategy for Oregon (Hagen 2011) for details on conservation actions and data gaps of particular need for sage-grouse in Oregon. Conservation actions include minimizing the effects of predation on isolated and declining populations where predation has been identified as a potential limiting factor (Hagen 2011), such as the Baker sage-grouse population. Identified data gaps included basic ecology, population ecology, migration of sage-grouse, and sagebrush ecology (Hagen 2011). This study will gather data to address all of these data gaps. The sage-grouse information will be gathered in four PACs where little data has been collected regarding habitat use, movement, and demographic rates of sage-grouse. Our study will also identify other potential conservation issues for sage-grouse within the Baker, Bully Creek, Cow Lakes, and Soldier

Creek PACs, which will be achieved by quantifying sage-grouse relationships to habitat characteristics and anthropogenic features.

This study also aligns with Work Plan Opportunity 7, "Assess the interactions between ravens and sage-grouse population dynamics in the Baker PAC" in the Baker Local Implementation Team's (Baker LIT) Comprehensive Threat Reduction Plan and SMART Goal 4-3, "By 2024, increase sage-grouse nest success and population trend within the Baker LIT Planning Area by reducing nest depredation from ravens through a 25% reduction in raven subsidies," in the Baker LIT FIP Strategic Action Plan (Baker LIT 2018).

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Appendix B: Population Model

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Introduction

The U.S. Fish and Wildlife Service developed this population model to assess the potential effects of experimentally removing Common Raven (*Corvus corax*) nests and adults from a portion of Baker County, OR to assist with recovery of Greater Sage-Grouse (*Centrocercus urophasianus*). High raven densities may negatively affect sage-grouse survivorship and productivity, and this study would evaluate the effectiveness of raven removal on improving those measures. The study design, purpose and need for the action, and analysis of effects of the action are described in the body of this Final Environmental Assessment and in Appendix A.

This analysis evaluates the effects of the proposed study at two scales: the Baker PAC and the Great Basin. Baseline population estimates for the Great Basin were based on survey data and analyses conducted by Coates et al. (2020) which yielded a mean raven density ± standard error SE of 0.54 ± 0.07 individuals/km^2 for the Great Basin (encompassing 746,937 km^2; see Figure 1 in Coates et al. 2020). Raven mean density was 0.44 ± 0.08 individuals/km^2 for the Baker Priority Area for Conservation (1,361 km^2; Baker PAC hereafter; L. Perry, pers. comm.). Here, I assessed raven population dynamics at Baker PAC under the four management scenarios below, as well as raven population dynamics at the Great Basin scale inclusive of the maximum take of the management scenarios plus the cumulative impact of other authorized take of ravens in the Great Basin.

Management scenarios:

1. No action taken (baseline or reference mode; Alternative 1).
2. Remove up to 55 nests/year (equivalent to denying 55 breeding pairs from successful reproduction) for 3 consecutive years; stop nest removal after third year (Alternative 2 and Scenario 1 of Alternative 3).
3. Remove up to 55 nests/year for 2 consecutive years; stop nest removal after second year; then harvest up to 400 ravens/year for 2 consecutive years; stop raven harvest after the fourth year (Scenario 2 of Alternative 3).
4. No nest removal, but harvest up to 400 ravens/year for 3 consecutive years; stop raven harvest after third year (Alternative 4).

Methods

Assuming logistic population growth, I estimated Prescribed Take Level (PTL; Runge et al. 2009) as:

$$PTL = F \times r_{max}/2 \times \hat{N}$$

where

F = management factor,

r_{max} = the maximum intrinsic rate of population growth, and

$\hat{N}$ = estimated population size.

The parameters, $\hat{N}$ and r_{max}, were randomly sampled from statistical distributions with the estimated raven population size for the Baker PAC and Great Basin described above for $\hat{N}$. See below for methods used to estimate r_{max}. .

The management factor, F, can range from 0 to 2. I set the management factor equal to 2 to reflect a harvest strategy in which the harvest rate is equivalent to the intrinsic population growth rate, r_{max} (Runge et al. 2009). Thus, I have analyzed the least conservative harvest strategy that corresponds to harvest in nuisance control situations.

I estimated the posterior distribution of r_{max} using the Demographic Invariant Method (Niel and Lebreton 2005) and conducted Monte Carlo simulations with program R (R Development Cor Team 2020) based on raven demographic rates reported in Boarman and Heinrich (2020). I also estimated r_{max} using a Bayesian state-space logistic model (Rivera-Milán et al. 2016). These methods were informed by Breeding Bird Survey count data for Nevada, Oregon and Utah in 1968–2019 (https://www.pwrc.usgs.gov/bbs/). The Bayesian state-space modeling framework was used to account for the variances of process and observation error (Rivera-Milán et al. 2016). The state dynamics of the population were modeled with a discrete form of the standard logistic equation. Annual changes in population state (Nt) were calculated with

$$N_{t+1} = N_t + r_{max} N_t \left[1 - \left(\frac{N_t}{K}\right)\right] - H_t$$

where:

r_{max} = maximum intrinsic rate of population growth,

K = population carrying capacity,

N_t = true unknown state of the population, and

H_t = total number of ravens harvested in year t. $H_t = N_t h_t$, where h_t is the harvest rate between time period t and $t + 1$ (Runge et al. 2009).

Harvest rates were randomly generated as part of the Markov chain Monte Carlo (MCMC) algorithm using the uniform distribution (i.e., $h \sim$ uniform [0.001, 0.700]). The unknown population state was re-parameterized as a proportion of population carrying capacity (N_t/K) to reduce autocorrelation in the MCMC samples. The error of state model predictions (ε) was assumed to be lognormally distributed with mean 0 and an estimated standard deviation (σ_{process}). Based on this re-parameterization, the state dynamics were projected forward in time according to

$$P_{t+1} = \left[P_t + r_{max}P_t(1 - P_t) - \frac{H_t}{K}\right]e^{\varepsilon_t}$$

The population proportion in year 1 (P_1) was modeled using a lognormal distribution with mean (P_0) and variance (${\sigma^2}_{P_0}$). That is,

$$P_1 \sim Lognormal\left(P_0, {\sigma^2}_{P_0}\right).$$

Population size (y_t) and observation error (${\sigma^2}_{t,observation}$) were directly estimated from the Breeding Bird Survey data. Because the distribution of abundance estimates tends to be positively skewed, the lognormal distribution was used for the observation error. The abundance estimates were transformed to the natural logarithm scale by transforming the bootstrap SE to the SD of the corresponding lognormal distribution. To complete the observation model of the state-space formulation, true unknown population state ($N_t = P_t K$) was related to observed population estimates with

$$\log(y_t) = \log(P_t K) + u_t$$

where

$$u_t \sim \text{Normal}(0, {\sigma^2}_{t,observation})$$

Lastly, assuming linear density dependence, maximum sustainable harvest rate was derived as

$$h_{msy} = \frac{r_{max}}{2}$$

The model formulation was simplified by assuming that harvest mortality occurred after the raven reproductive peak and that age classes (juveniles, adults) had equal mortality probability. In addition, additive mortality (i.e. all mortality resulting from natural events and human activities) was assumed, although the model formulation allowed for density-dependent compensation. Uniform prior distributions were used for maximum population growth rate (r_{max} ~ uniform [0.001, 2.000]), population carrying capacity (K ~ uniform [1,000, 10,000]), and the mean of the initial population proportion on the logarithmic scale (P_0 ~ uniform [−5, 0]). For the process and initial population proportion SD, uniform priors were also used ($\sigma_{process}$ and σ_{P_0} ~ uniform [0, 5]).

To estimate the posterior distributions of r_{max} and h_{msy}, Markov chain Monte Carlo (MCMC) was used by running program JAGS, version 3.4.0 within R2JAGS (Su and Yajima 2015, http://mcmc-jags.sourceforge.net). The first 50,000 of 250,000 iterations were used as a burn-in period. Three Markov chains with different initial parameter values were generated, and trace plots and node summary statistics were used to check for MCMC algorithm convergence. Markov chains were thinned by 25 to obtain samples of 8,000 points. Results are presented as means ± MCMC SD, and 2.5%, 50%, and 97.5% percentiles.

Lastly, I used a system dynamics simulation to model raven population dynamics under the proposed control management scenarios for the Baker PAC (Figure B-1; Ford 1999). For system dynamic simulations, I assumed a population carrying capacity K of 1,000 ravens and 70 nesting territories. I also generated initial abundances randomly from uniform distributions ranging from 50 to 100 nests (i.e., N_0 = 78) and from 500 to 1,000 ravens (i.e., N_0 = 596). Lastly, I used uniform distributions to account for uncertainty in demographic rates and r_{max} but held other parameters constant (e.g. raven harvest rate h and nest removal rate = 0.01 or 0.70).

Results

Based on the Demographic Invariant Method, and assuming adult annual survival rate and age at first reproduction were 0.5–0.9 and 2–3 years-old, respectively, r_{max} ranged from 0.152 to 0.390 (Table B-1). I obtained similar r_{max} values with the Bayesian state-space logistic model and system dynamics simulations (Tables B-1 and B-2).

Based on system dynamics simulations (i.e., means ± SDs from 100 model runs; Figure B-1), under Alternative 1 (the No Action Alternative), the Baker PAC would have 74 ± 1 nests and 850 ± 85 ravens in year 5, with 68 ± 1 nests and 960 ± 24 ravens in year 15 (Figure B-2). Under Alternative 2 (Nest Take Only), the Baker PAC would have 2 ± 1 nests and 671 ± 77 ravens in year 5, with 67 ± 6 nests and 954 ± 28 ravens in year 15 (Figure B-3). Under Alternative 3 there are two potential outcomes. The first outcome is identical to Alternative 2 (three years of nest take). The modeled results from second outcome, nest take during years one and two followed by adult take in years three and four, are that the Baker PAC would have 27 ± 8 nests and 185 ± 41 ravens in year 5, with 64 ± 7 nests and 762 ± 145 ravens in year 15 (Figure B-4). Under Alternative 4 (Adult take only) the Baker PAC would have 74 ± 1 nests and 144 ± 40 ravens in year 5, with 68 ± 1 nests and 692 ± 181 ravens in year 15 (Figure B-5). Results from all models are displayed in Table 1 of the Final EA.

With survey-based estimate of population size $\hat{N}$ = 403,346 ± 52,435 SE ravens (Coates et al. 2020) and model-based posterior distribution with mean r_{max} = 0.305 ± 0.014 SD (Table B-2; Rivera-Milán et al. 2016), harvest rates $h < 10\%$ would not cause a population decline in the Great Basin and adjoining shrub-steppe ecoregions (Figure B-6). Based on standard harvest theory and logistic growth (Runge et al. 2009), the raven population in the Great Basin and adjoining shrub-steppe ecoregions probably can sustain harvest rates $h < 20\%$ (i.e., maximum sustainable harvest rate $h_{msy} = r_{max}/2 = 0.152/2 = 0.076$ and $0.390/2 = 0.195$; Tables B-1 and B-2).

The implications of these model results are discussed in the Final Environmental Assessment.

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Table B-4: r_{max} estimates under Demographic Invariant Method

ϕ	0.5	0.7	0.8	0.9
α	2	2	2	2
r_{max}	0.39	0.319	0.27	0.2
α	3	3	3	3
r_{max}	0.274	0.232	0.2	0.152

ϕ = Adult survival rate

α = Age at first reproduction

Table B-3: r_{max} estimates under Bayesian State-Space and System Dynamic models

Method	r_{max}	SD	Percentiles 2.50%	50.00%	97.50%
Bayesian state-space	0.305	0.014	0.269	0.309	0.319
System dynamics	0.321	0.03	0.252	0.258	0.383

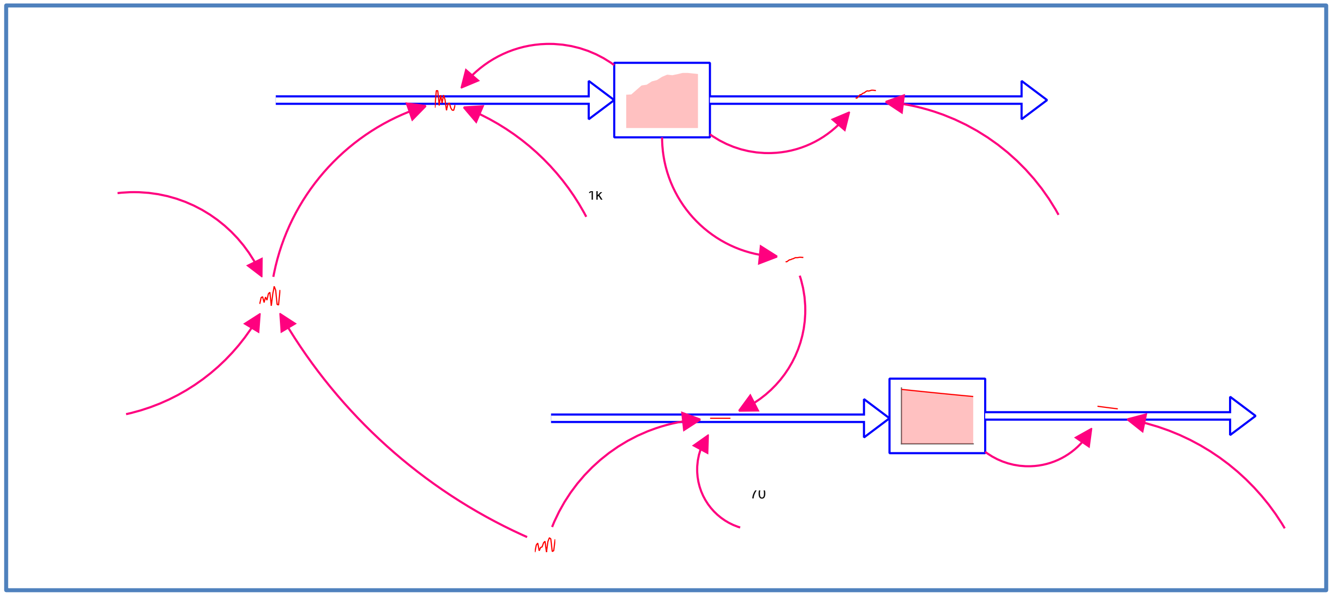

Figure B - 1: System Dynamics Model[1] of Baker Pac Raven Harvest and Nest Removal

1 – Model Parameters:

- Runs = 100
- Nests(t) = Nests(t - dt) + (Reproduction - Removal) * dt
- Nests N_0 = 78
- Reproduction = Productivity_rate*Breeding_pairs*(1 - Breeding_pairs/Nesting_territories)
- Removal = Nests*Removal_rate
- Ravens(t) = Ravens(t - dt) + (Inflow - Outflow) * dt
- Ravens N_0 = 596
- Inflow = Ravens*Rmax*(1-Ravens/Carrying_capacity)
- Outflow = Ravens*Harvest_rate

- Adult_survival_rate = uniform (0.7, 0.9)
- Breeding_pairs = (Ravens/2)*0.26
- Ravens K = 1000
- Harvest rate = 0.01 (low) or 0.7 (high)
- Juvenile_survival_rate = uniform (0.5, 0.7)
- Nesting_territories K = 70
- Productivity_rate = uniform (1, 4)*(1 - uniform (0.4, 0.9)^1)
- Removal_rate = 0.01 (low) or 0.7 (high)
- R_{max} = (Adult_survival_rate+Juvenile_survival_rate*Productivity_rate) - 1

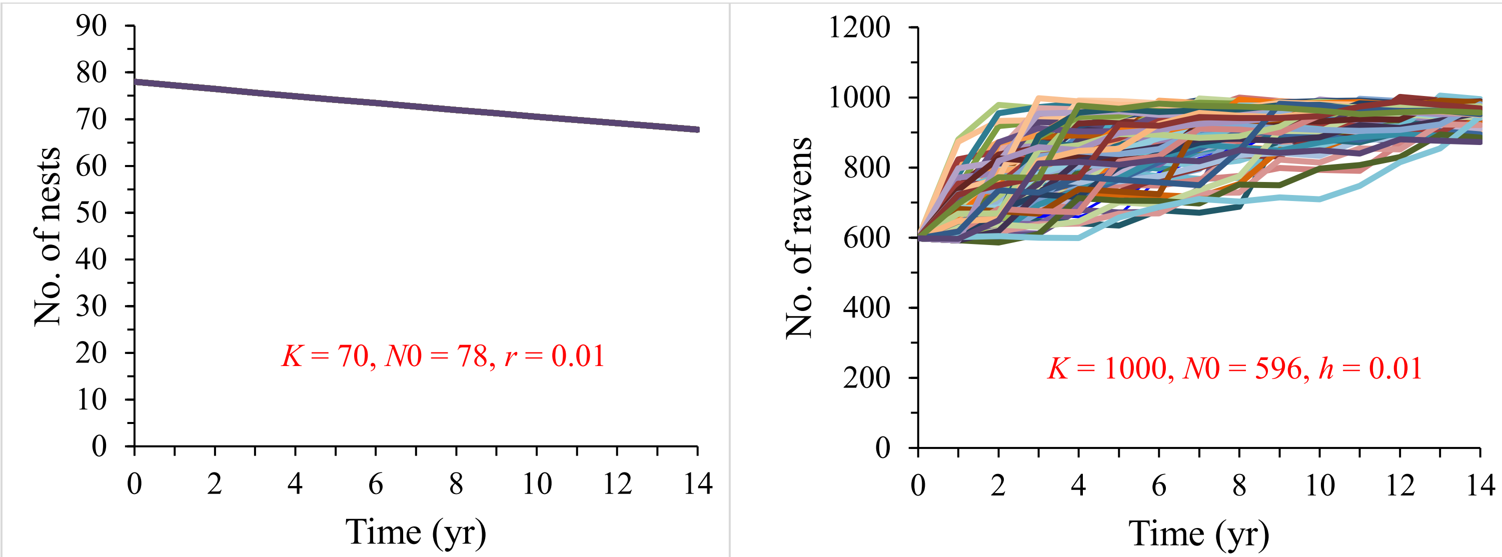

Figure B - 2: Alternative 1, Nest Removal Rate (r = 0.01) and Raven Harvest Rate (h = 0.01) Yr 0 – 14.

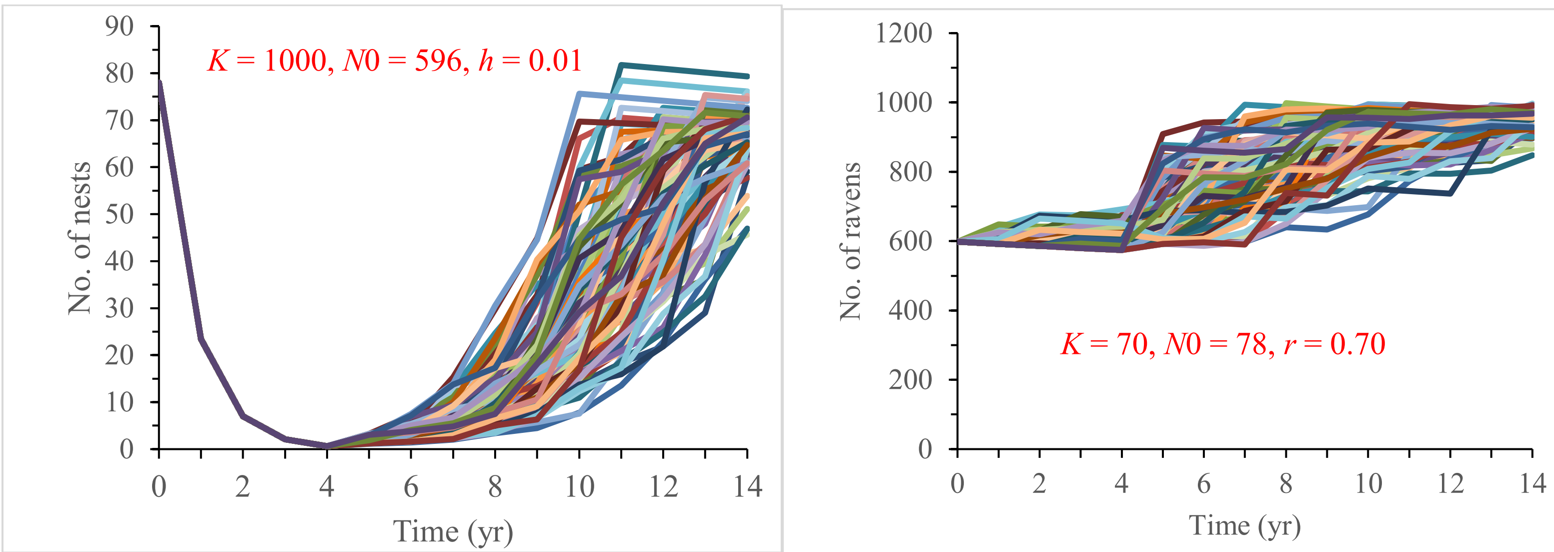

Figure B - 3: Alternative 2, Nest Removal Rate (r = 0.70) Yr 1 – 3 and Raven Harvest Rate (h = 0.01) Yr 0 – 14.

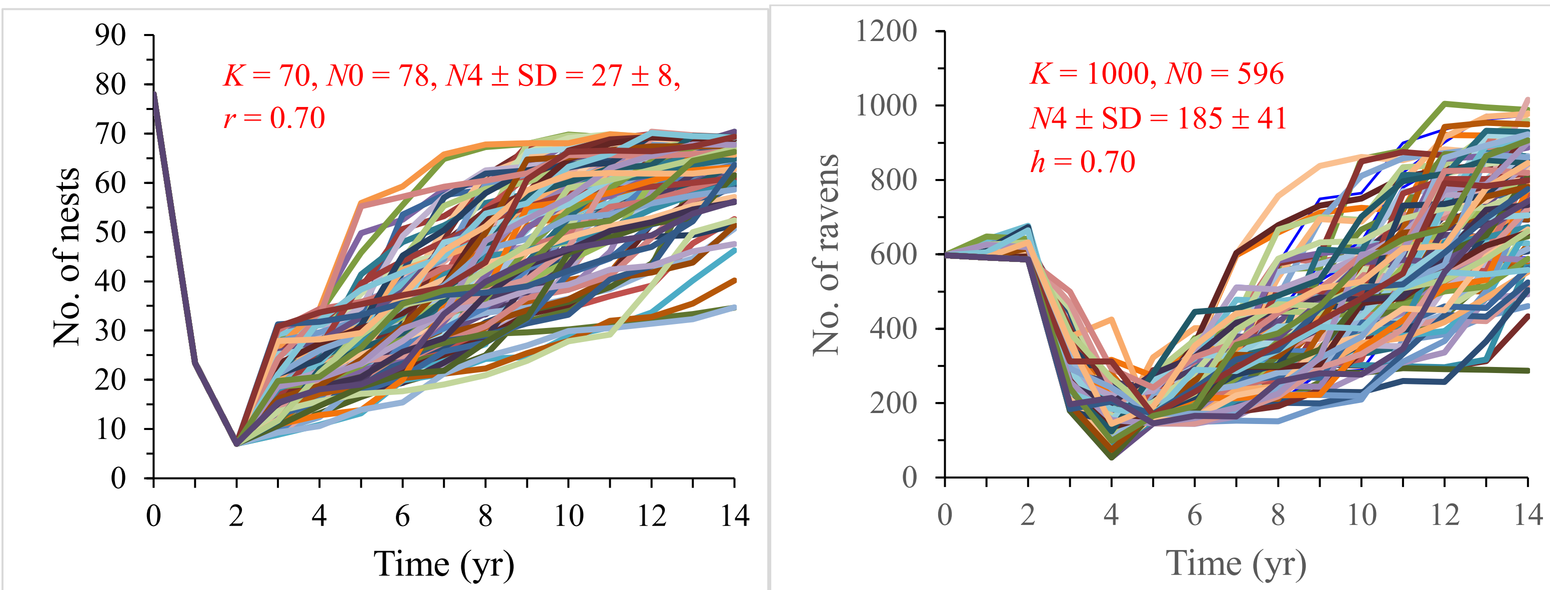

Figure B - 4: Alternative 3, Scenario 2, Nest Removal Rate (r = 0.70) Yrs 1 – 2 and Raven Harvest Rate (h = 0.70) Yrs 3 – 4.

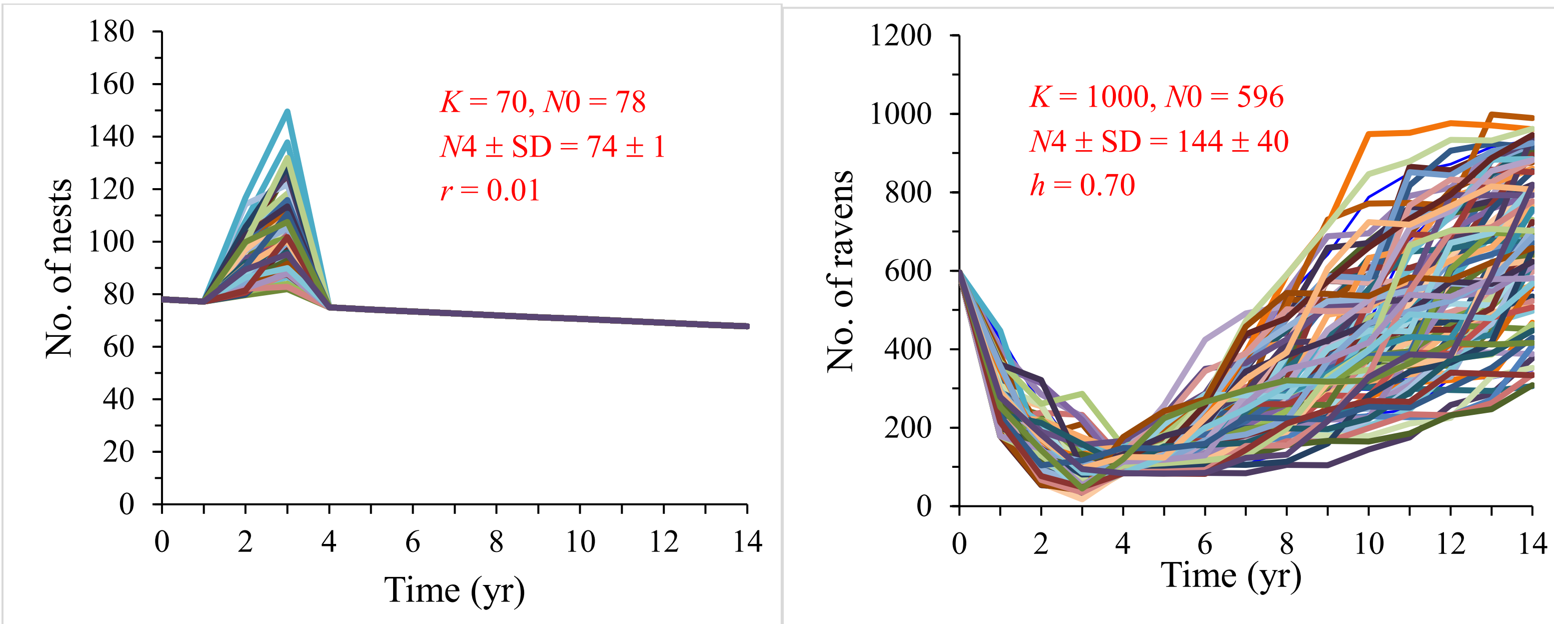

Figure B - 5: Alternative 4, Nest Removal Rate (r = 0.01) Yrs 0 – 14 and Raven Harvest Rate (h = 0.70) Yrs 1 – 3.

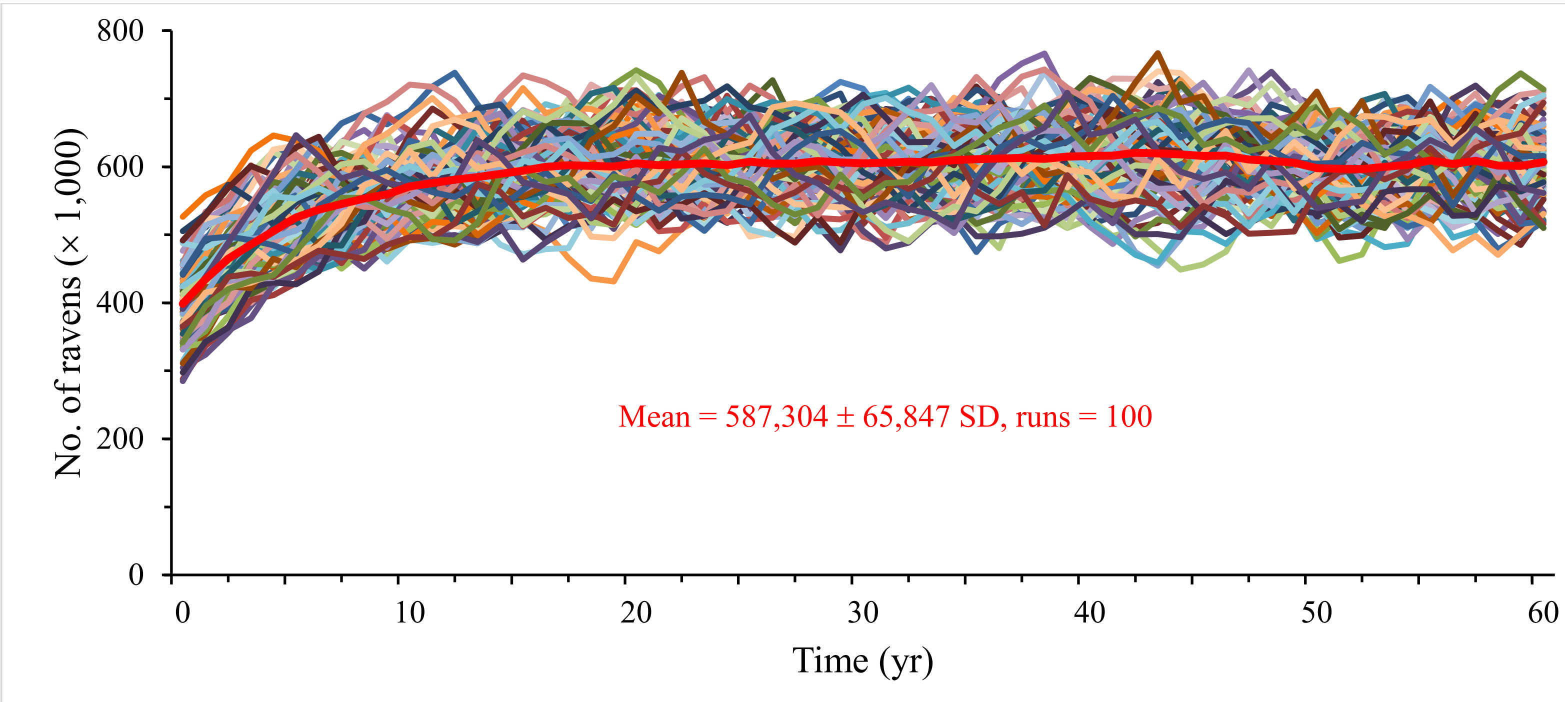

Figure B - 6: Raven Harvest (h = uniform [0.01, 0.1]), in the Great Basin.

Appendix C: Responses to Public Comment

Table C-1: Summary of substantive public comments received during 30-day public comment period for the January 8, 2021 Draft EA.

#	Summary of Comment	Response
1	The EA was released too late for ODFW to implement a credible first year of study, compromising the results and interpretation of the results for subsequent years, in the adaptive management framework. This could inadvertently lead to adult take in years 2 and 3 if the insufficient results in year one show no effectiveness in improving sage-grouse productivity. Additional years of nest take should be used before implementing adult take.	Ravens likely will not begin nesting in Baker County, Oregon until mid- late-March, and the first chicks hatch mid- to late-April. ODFW has told the Service that they do expect that they will be able to conduct a full field season of nest removal in 2021 within the remaining window before raven chicks begin to hatch. In addition, ODFW is now implementing nest removal for two years before evaluating its effectiveness. Also, researchers at Oregon State University know the nesting locations of ravens in the Baker PAC from three prior years of study. Many pairs will re-nest in those same or nearby locations.
2	ODFW does not have any data that directly implicate ravens as nest predators of sage-grouse in the Baker PAC, despite the use of telemetry on nesting sage-grouse and the availability of nest cameras to document predation events.	Although researchers have not witnessed, to date, ravens depredating sage-grouse nests, sage-grouse egg shells have been found at raven nest sites in the Baker PAC. Techniques to directly assess nest predation events, e.g. cameras placed near nests, can attract the attention of predators and put the nest at risk of predation. The Baker population is very small and is especially vulnerable to decreases in nest success that could occur using this technique.

		In addition, there is overwhelming evidence (presented in the EA) that sage-grouse nest success declines with increases in common raven densities. It is logical to infer from the high raven density and low sage-grouse nest success in the Baker PAC, in light of findings from existing studies demonstrating a causal relationship between the two, that ravens may be contributing to sage-grouse nest failure in the Baker PAC. This Before-After, Control-Impact study is designed to investigate this relationship in the Baker PAC.
3	Agencies should address more significant causes of sage-grouse decline, including adequately implementing the 2015 Oregon Sage-Grouse Plan, and increase protections from disturbance from OHV use.	This comment is unrelated to the scope of this NEPA analysis, which is an analysis of the scientific collecting permit application from the Oregon Department of Fish and Wildlife. The analysis does not require consideration of all conservation actions for sage-grouse that have or have not been done by other agencies prior to this permit issuance.
4	Risks associated with the use of DRC-1339 were not adequately addressed. The Draft EA failed to disclose how ODFW will collect carcasses of poisoned ravens? It did not consider that non-target species will consume cached baits or those that are left in the environment. The bioenergetics model cited has not yet been published. The amount of toxicant used in the eggs is more than enough to kill non-target birds, and maybe other egg predators as	The toxicity of DRC-1339 is very low for mammals; a lethal dose to a squirrel would require it to consume hundreds of eggs. Birds that might consume baits and be susceptible include other corvids, including magpies and crows. These species are unlikely to find caches by ravens or gain access to them. In addition, bait stations are monitored; if non-targets find and use bait stations the stations will be relocated. The risk of secondary poisoning of non-target animals is negligible as well. DRC-1339 breaks down rapidly in the environment, and raven carcasses are unlikely to contain levels that would put scavengers, including domestic pets, at risk. See Section 5.2.2. The bioenergetics model referenced in the EA is still in press.

	well. And there is a risk to poisoning of domestic pets which might find cached eggs.	
5	ODFW has not provided clear and measurable evaluation goals to justify a decision to move from nest removal in one year to lethal removal the following year. This includes a lack of clarity of the level of effect in raven occupancy, density, or nest success, and of sage-grouse nest success. There is no discussion about how confounding factors such as weather and the influence of other predators will be accounted for in the analysis.	The Before-After-Control research study designed by ODFW will allow them to measure an increase or decrease in sage-grouse nest success by comparing the difference from before raven management began in the Baker PAC to after, in any given year of this study, and also in relation to reference areas (control sites). According to ODFW, a Year-by-Treatment interaction will be an informative parameter in the model and will indicate whether or not management has improved sage-grouse nest success. This will be based on 85% CI, where year will be included before and after treatment and treatment will be defined as either the Baker PAC or Reference areas. A measurable evaluation criterion will also include sage-grouse nest success of >26%, based on Figure 3 in Coates et al. (2020). This nest success rate is equivalent to the overall average of sage-grouse nest success in the Great Basin. Nest success above 26% is likely to produce stable or increasing sage-grouse populations. Two metrics will be measured to determine if ravens have been adequately reduced. The first metric is a reduction in active raven nesting territories, measured by a change in raven nest occupancy, within sage-grouse nesting habitat during the sage-grouse nesting season. The second metric is a reduction in local raven density (to 0.15/ravens/km^2 or below) within sage-grouse breeding habitat (as measured by point count surveys). If point count surveys conducted after raven nest removal indicate that the local raven density during the sage-grouse breeding season is at or below the level which limits sage-grouse nest success, this will indicate nest removal efforts were successful. The baseline estimate for raven territories is derived from GPS-marked birds. Raven densities are also estimated from point count surveys, as defined in this EA, from data collected to date.

		The decrease will be defined as a lower raven nest occupancy rate than the average nest occupancy rate from 2018-2020. Using a Before-After-Control design, ODFW will be able to tease out the effects of weather and other predators in the data. In the analysis, ODFW's base models will incorporate year and site covariates, cited from other recent sage-grouse/raven research. ODFW will conduct an analysis similar to Dinkins et al. (2016), where weather was specifically incorporated into the models to account for interannual variation. Predation from non-ravens is accounted for in the BAC design as well. Management is focused on reducing raven impacts on sage-grouse. Nest success trajectory differences will be evident between the treatment and control sites. Ravens are being held at a higher carrying capacity on the landscape, due to anthropogenic subsidies, unlike other nest predators. There is a difference between subsidized and non-subsidized nest predators in sagebrush habitats. Sites (lethal, non-lethal, and control) don't need to be identical in the BAC design. The change in trend is of individual response variables is what is evaluated. Our reference sites have fairly stable populations. Multiple reference sites are included to account for this potential variability among sites.
6	More detail is needed to describe how control and non-lethal sites were selected and how they will be integrated into the research design. Also, more detail is needed as to how nest surveys and removal activities will be conducted, and how egg baits will be	The Baker PAC was chosen due to its sage-grouse population status and documented high raven densities. The Cow Lakes PAC has a similar conservation status as Baker PAC; it has hit BLM population and habitat triggers, like Baker, and so was chosen to receive non-lethal treatments. Management actions that minimize raven depredation on sage-grouse nests in either Baker or Cow Lakes should be similar between the two sites, regardless of lethal or non-lethal action.

	deployed and non-target or excessive raven take will be avoided.	Further, the Baker PAC is an isolated, distinct population and has greater conservation concern than the Cow Lakes PAC. This is the reason ODFW plans to implement management actions (lethal) that have been well-documented to improve sage-grouse nesting success in this PAC. If Baker PAC sage-grouse are extirpated, there are no birds to immigrate, making reestablishment of this population exceedingly difficult or impossible. Research crews, local biologists, and private landowners will inform ODFW of known raven nests. Location and date of removed nests will be well documented. Biweekly surveys will be conducted at these nest sites to monitor for re-nesting attempts, as described in the EA. In the EA, we describe how eggs will be used in bait stations and how non-target take will be monitored. A conservative amount of DRC-1339 will be used, making excessive take by ravens improbable.
7	The effects of other predators not fully considered, including squirrels and other corvids. Compensatory predation was also not considered. If there are any benefits from raven control they are short-lived. There is no discussion about the potential for livestock to trample nests.	Although there is always some natural level of depredation by a suite of predators, their populations are generally not artificially high due to human subsidies as raven populations are across the Great Basin. Compensatory predation does not act similarly in this system as it does a system that is void of subsidized predators. Higher raven densities have consistently been demonstrated to lower sage-grouse nest success. Research by Lockyer et al. (2013) in northwestern Nevada indicated common ravens were the most frequent nest predator of sage-grouse. Squirrels were only documented to eat one live egg and would very rarely roll an egg out of the nest bowl. Coates et al. (2008) document several ground squirrels at sage-grouse nests, but they couldn’t pierce the viable (live) eggs and they didn’t cause nest failure.

		The study is a 4-year study, and the effects of the study on ravens and sage-grouse will extend for the duration of this study. The purpose of the study is to experiment with strategies that might effectively improve sage-grouse productivity in the short-term. The longer-term strategy is to improve habitat conditions for sage-grouse. The sage-grouse population in Baker is sensitive to extirpation, so we need to use short-term and long-term management solutions. Livestock trampling of sage-grouse nests is very rare. In two intensive video studies on sage-grouse nests, only one livestock trampling event was documented, and only one egg was destroyed (Coates et al., 2008; Lockyer et al., 2013).
8	The range of raven nesting territories that were estimated (37-268) demonstrates that ODFW did not adequately survey for raven nesting territories. The proposed nest take (100/yr.) may be more than the actual number of nests on the landscape. There is no justification for the aggressive target density of 0.15 ravens/km^2.	Data from researchers studying ravens in the Baker PAC are cited in the EA, and they demonstrate that the density of raven nests in that PAC is within the range of ravens found elsewhere, and is conservatively estimated at about 48 nests. Additionally, the raven density is supported by point count surveys and is independent of the range of nesting territories estimated. We acknowledge that the take of 100 nests per year is likely more than the actual number of actively nesting pairs in the Baker PAC. We choose 100 because some pairs might re-nest. One hundred accounts for 1st, 2nd, and in some cases 3rd nesting attempts by each pair. The target raven density of 0.15 ravens/km^2, after removing adults from the Baker PAC population, comes from a combination of studies (Dinkins et al. 2016, Peebles et al. 2017), where a reduction to 0.15 ravens/km2 resulted in an increase in sage-grouse nest success and resulting higher sage-grouse lek counts. Coates et al. 2020, Figure 3, indicates a reduction of raven density to 0.15 ravens/km2 would yield a slightly above average sage-grouse nest

		success, resulting in a slightly growing sage-grouse population. The target density aligns with the density of ravens in relatively intact sage-grouse habitat (Coates et al., 2020). A large proportion of the entire raven population is of non-breeding birds. The focus by ODFW only on breeding adults is a targeted, conservative approach, and born from research indicating pairs holding territories in sage-grouse nesting habitat have a disproportionately negative effect on sage-grouse productivity, and that by manipulating those ravens nests, can result in positive effects to sage-grouse (Harju et al., 2018).
9	The analyses for No Action and Nest-take Only alternatives (Alt 1 & 2, respectively) both anticipate raven density increases without accounting for the fact that the PAC may be at carrying capacity.	The model assumes the number of ravens nesting now in the Baker PAC is 78, and above a carrying capacity of 70. This is why the number of nesting territories declines over time (Figure B-2). The nesting carrying capacity is estimated from data in Howe et al. 2014; we assumed the number nesting now is somewhat above that level, based on the number of known nesting locations and the area covered by recent surveys. In contrast, the model assumes the population of ravens now in the Baker PAC is 596, below the estimated carrying capacity of 1000. This is why the model shows an increasing population of ravens from year 0 through year 15 in various modeling scenarios (e.g. Figure B-5). The starting population number of ravens is derived from density estimates in the Baker PAC, and the carrying capacity is assumed to be higher than current, based on the higher density estimated in the Great Basin, and the continuing growth of the population in the Great Basin (Coates et al. 2020). Regardless of the exact numbers, raven populations have a demonstrated capacity to grow under current conditions in Great Basin environments, and the population models we used reflect that reality.
10	The FWS dismissed public concern regarding the risk of incidentally killing	We addressed this issue in Response number 11 in the Draft EA; in our response we merely pointed out the effect the new rule under MBTA (https://www.fws.gov/regulations/mbta/)

	other MBTA-protected birds through use of DRC-1339, because of proposed changes to the MBTA protections. That new rule is unlikely to stand-up to legal challenges, and regardless, that the Service still has an obligation, consistent with its core mission, to minimize negative impacts to non-target species. To do otherwise is wanton waste and puts the US Fish and Wildlife Service fundamentally at odds with basic conservation ethics and its own mission.	would have regarding the treatment of incidental take from a legal perspective. The Service does not dismiss the public concern for considering the potential of any action to result in incidental take of birds. The Service extended the implementation date of the new rule regarding incidental take until March 8, 2021, and accepted additional public comment until March 1, 2021. The agency will consider those comments in its deliberations about next steps regarding the proposed new rule.
11	An EIS is required because there will be significant impacts from the proposed action do to context and intensity of the action. Specifically, effects will be significant from the standpoint of the controversy surrounding the action, uncertainty surrounding the justification for and results of the action, the unique character of the Baker PAC area, and due to the precedent of the action.	New regulations implementing NEPA allow agencies to determine significance, and no longer define significance based on context and intensity. The underlying argument that this experiment is controversial is attributed to a lack of evidence that ravens depredate sage-grouse nests in the Baker PAC. See our reply to comment #2. There is nothing precedent setting in this experiment, nor anything particularly unique about the Baker PAC. All of the proposed actions have taken place previously in similar habitats elsewhere across the Great Basin. There are 188 sage-grouse PACs across 11 western states, and most of those closely resemble the habitat in the Baker PAC. There is uncertainty about the outcome of this experiment, as there is surrounding the outcome of any scientific endeavor; that, alone, however does not automatically qualify this analysis for a more in-depth NEPA analysis. There is certainty about the point of the analysis, however, and that is that raven populations will recover in the Baker PAC following

		the experiment, and will continue to grow across the Great Basin regardless of it. Also, sage-grouse in the Baker PAC will likely benefit from this experiment, and non-target effects will be negligible. We reached these conclusions following population modeling and relying on the extensive literature of similar studies across the west, and therefore determine that this action will not have a significant effect on the human environment.
12	The FWS failed to analyze the effects of non-lethal actions for lowering raven densities; as these are connected, interdependent actions, they need to be analyzed in greater detail.	We analyzed the effects of non-lethal control and concluded that the effects of non-lethal actions proposed to take place in the Cow Lakes PAC, e.g. food subsidy removal and raven nest site destruction, will likely lower raven nest success, nest density, and might cause ravens to disperse to other areas. The effects on sage-grouse would likely be beneficial. A discussion of these effects is primarily discussed under the No Action alternative in the EA, and referred to under each of the other alternatives analyzed.
13	Trophic cascades not analyzed (e.g. system dynamics with removal one predator).	Ravens will not be completely eliminated from the Baker PAC landscape under this study. If nest take is implemented each year, then there will be no reduction in raven numbers over the course of the study (Figure B-3). If adults are taken, then raven numbers will recover within a few years of the study (Figures B-4 and B-5). There might be time within this span for other predators to fill a predatory niche left vacant by lower densities of ravens. However, in our analysis we do consider the impacts that other predators in sagebrush ecosystems may affect sage-grouse, and the degree to which ravens in higher than normal densities exert unusual predatory pressure on nesting sage-grouse. Removal studies have only shown improvements in sage-grouse nest survival, not increased predation by other predators. See Section 7.2 of this EA.
14	The Purpose and Need of the EA is to compare the effectiveness of lethal and	The purpose of this EA is to evaluate the environmental effects of authorizing raven take under a scientific collecting permit that ODFW applied for; the need to do so is because the

	non-lethal techniques to lower raven density. However, the EA fails to define parameters for success under non-lethal methods therefore making a comparison impossible.	Service is required to make permit decisions on permit applications (see Section 2 of the EA). Regardless, non-lethal and lethal methods of lowering raven density are discussed more thoroughly in the reply to comment number 5.
15	The Local Implementation Team is addressing threats to sage-grouse other than raven, but those actions are slower, long-term actions. The Integration of lethal with non-lethal actions will inform further management decisions to save Baker PAC sage-grouse. This study was called for in Threat Reduction Plan issued by the Local Implementation Team.	This study is born out of the Baker Local Implementation Team's Threat Reduction Plan. We agree that it is likely that the results of this study, which includes both lethal and non-lethal components, will inform future sage-grouse management both in the Baker PAC and in other PACs.
16	Would like to have seen the lethal take level proposed in the 2018 Draft EA maintained in this one. ODFW was overly-influenced by comments submitted on the first draft EA, by those who do not reside in Baker County, and reduced the take levels as a result.	The study proposed by ODFW in this EA is a reflection of new studies across sage-grouse country (particularly by Harju), additional data from the Baker PAC, and consideration of public comments on the initial EA. The methods and take levels proposed in this new version of the study will likely be sufficient to detect whether or not managing raven populations will benefit sage-grouse.

17	Baker County was not consulted, as tribes were, and this is a violation of the Congressional Law of Coordination mandate.	Baker County was invited by email to comment on both Draft EAs, the first one issued February 2019 and the most recent one, January 2021. The county submitted comments on both Draft EAs. The County is also an official member of the Local Implementation Team, and as such was informed of this study as it developed. The United States Government has a unique relationship with American Indian governments as set forth in the Constitution of the United States, treaties, statutes, judicial decisions, and Executive orders and Presidential memorandums. As such the U.S. government engages with tribes in government-to-government relationships on issues that may affect tribal interests.
18	Ravens are part of the ecosystem and have been here for thousands of years. Ravens are intelligent, highly social, have a culture passed down through generations.	Ravens are indeed highly social and intelligent. They belong to a family of birds, Corvidae, which as a group are noted for being inquisitive, demonstrate sophisticated problem-solving skills, and are adaptive. It is likely these very skills have allowed ravens to adapt to a human-altered landscape. Their numbers are now much higher than historically and continue to grow. Common ravens are also skilled predators, learning quickly how and where to find easy prey, e.g. nests, on the landscape. Ravens in high densities can act to depress populations that they prey upon, including sage-grouse. Thus, while admirable for their intelligence, beauty, and character, ravens in unusually high numbers can pose a serious threat to other, less adaptable and more vulnerable species.
19	Removal of protected migratory birds should only be done as part of a high	Birds may be taken legally under the Migratory Bird Treaty Act by permits that are described under 50 CFR Part 21. A Scientific Collecting permit is available under 50 CFR 21.23. ODFW applied for a permit under this regulation.

	quality scientific study. This would break the law and ignore the MBTA.	
20	Livestock are correlated with increased raven numbers; this research should consider a livestock removal option	There is no component of this study involving the removal of live cattle. However carcass removal is a component of this study (in the Cow Lakes PAC). It is reasonable to expect that ravens might benefit from livestock ranching operations if they take advantage of cattle carcasses left in the field, and this is being addressed by this study.
21	Human programs to regulate wildlife populations have bad consequences. They are morally abhorrent, bad science, and bad economics. Harming one species to assist another leads to imbalance in nature.	We acknowledge that not everyone agrees with the concept of human management of wildlife populations, but human programs to manage one species to benefit another can be effective particularly to allow at-risk species to recover while other longer-term management actions can occur. We know, for example, that raven control at other sites has benefited sage-grouse populations locally (see Section 5.3.2); that Western Snowy Plover on the Oregon coast have benefited from raven control (Lauten et al. 2017); and that species removals on islands have benefited numerous island ecosystems (https://www.islandconservation.org/). This proposed study is short-term, to examine the effects of raven management on sage-grouse; it is not being proposed as a long-term management strategy. After this study is concluded, were ODFW to propose to undertake management actions regarding ravens as a long-term strategy, a new permit application and new NEPA review would be required.
22	Sage-grouse declines have been studied for decades and there's no documentation of excessive egg predation by ravens.	There is quite a lot of research on ravens depredating sage-grouse nests, and evidence supporting the assertion that high raven populations suppress the recovery of sage-grouse and may lead to declines in their populations. See Section 7.2 of this EA.

23	Native Americans consider ravens a spiritual animal.	Ravens are held in special reverence by many tribes. Out of concern for the importance of ravens in tribal history, story, and iconography, we requested comments from and gave early notification to tribes in the Pacific Northwest regarding the availability of the proposed study here and the Draft EA assessing its effects
24	The EA fails to detail how the proposed actions did not consider Bureau of Land Management plans. Not enough information was given as to what actions would take place on BLM land versus private land. ODFW may need to seek approval from BLM for activities conducted on BLM lands.	Additional coordination between ODFW, BLM, and the FWS has occurred since the posting of the Draft EA. We discussed how the proposed study will be conducted and whether or not the study would conform to BLM land use plans in the Cow Lakes and Baker PACs. ODFW has agreed that their study will conform to those land use plans, and we added Section 6 to the EA reflecting that coordination.
25	Raven numbers are increasing and having a negative impact on sage-grouse.	Long-term monitoring of ravens, and several studies across sage-grouse habitat in the west, support this assertion. This study is designed to look specifically at potential management solutions to raven depredations on sage-grouse.
26	If sage-grouse continue to decline, they might be listed under the Endangered Species Act. This would have harmful economic and social impacts to local communities.	Greater Sage-Grouse has been petitioned for listing in the past, and if declines continue across the west, it may face another listing petition in the future. Management solutions that will recover sage-grouse populations across western states need to be found. The result of this study might inform short-term management solutions for raven depredation issues.