Updated biological status review for the Gray Wolf (*Canis lupus*) in Oregon and evaluation of criteria to remove the Gray Wolf from the List of Endangered Species under the Oregon Endangered Species Act

Note: Though similar to the March 31, 2015 document presented to the Oregon Fish and Wildlife Commission on April 24, 2015, this review contains updated biological information through July 2015. In addition, it contains additional analysis and discussion regarding delisting a portion of Oregon (eastern Oregon Wolf Management Zone), and biological implications of a no-action decision by the Oregon Fish and Wildlife Commission.

Executive Summary

Oregon wolves are listed as an endangered species under the Oregon Endangered Species Act (OESA). The Oregon Wolf Conservation and Management Plan (hereafter Wolf Plan; ODFW 2010) contains a conservation population objective which was predicted to support the requirements for delisting the species under OESA. The conservation objective was achieved in January 2015 and this draft document is prepared to present information to the Oregon Fish and Wildlife Commission (Commission) on the biological status of gray wolves in Oregon.

Through natural dispersal from neighboring Idaho, wolves became established in Oregon in 2008 and have increased in both distribution and abundance during all years since that time. At the end of 2014 there were 9 successful breeding pairs of wolves in Oregon (Table 2). By July 2015, the known population (not including pups of the year) was 85 wolves, with reproduction having been documented in 13 packs or groups. Our analysis as part of this biological review predicts that Oregon’s wolf population will continue to increase.

Delisting a species from OESA (ORS 496.176) requires a public rulemaking and findings by the Commission and these decisions are to be made on the basis of scientific information and other biological data. Specifically, the Commission must evaluate the biological status of the species and determine if:

1. The species is not now (and is not likely in the foreseeable future to be) in danger of extinction in any significant portion of its range in Oregon or in danger of becoming endangered; and
2. The species’ natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human-related factors affecting its continued existence; and
3. Most populations are not undergoing imminent or active deterioration of range or primary habitat; and
4. Over-utilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is not occurring or likely to occur; and
5. Existing state or federal programs or regulations are adequate to protect the species and its habitat.

In this draft biological status review document we evaluated the status of wolves as related to each of these criteria for the entire state (Option 1), and also for the eastern Wolf Management Zone (WMZ) only (Option 2). Our evaluation resulted in the conclusions that: 1) wolves were once extirpated as a result of historical efforts to eradicate them, and now in absence of those efforts and under current management frameworks, are increasing in abundance and distribution; 2) there are no known conditions which prevent wolves from inhabiting currently unoccupied portions of range in Oregon or within the eastern WMZ; 3) observed movement and dispersal patterns indicate connectivity from source populations and 4) the probability of population failure is very low. We also included analysis and discussion (Option 3) regarding the biological implications of wolves remaining listed as endangered in Oregon.

Introduction

Historical accounts show that prior to extirpation from Oregon and other western states gray wolves (Canis lupus) were widely distributed and efforts by early Euro-American immigrants were largely directed at eliminating the predator (Oregon Department of Fish and Wildlife 2010). As a result, wolves were extirpated from most of the western United States by the mid-twentieth century. Modern recovery efforts in the Northern Rocky Mountains and subsequent conservation actions in the western United States has since led to restored gray wolf populations throughout a portion of its historical range.

In 1995 and 1996, the United States Fish and Wildlife Service (USFWS) reintroduced 66 gray wolves into the Rocky Mountains of Idaho and Wyoming. The reintroductions and associated conservation measures were part of the 1987 Northern Rocky Mountain (NRM) Wolf Recovery Plan and were responsible for the successful reestablishment of wolves in Wyoming, Idaho, Montana, and later in parts of Oregon and Washington. In 2014, the NRM wolf population (including Oregon and Washington) was estimated at 1,802 (U.S. Fish and Wildlife Service, 2015).

Though gray wolves were not reintroduced into Oregon, wolf experts predicted that wolves from a successful NRM population – especially Idaho – would eventually travel to and colonize Oregon. This prediction was soon realized and between 1999 and 2007, at least 4 individual wolves were documented to have dispersed into Oregon from Idaho. In July 2008, Oregon Department of Fish and Wildlife (ODFW) biologists discovered a wolf pack with pups in the Wenaha River area of northeastern Oregon and this was the first modern documented reproduction of wolves within the state. The Oregon wolf population has steadily increased and in 2014 ODFW documented a minimum known population of 81 wolves in 15 pairs or packs. By July of 2015 the minimum known Oregon population (not including young-of-the-year) was 85.

State and Federal Regulatory Status and Actions in Oregon

Wolves were classified as endangered in Oregon in 1987 when the Oregon Endangered Species Act (OESA) was enacted. The OESA requires the conservation of listed species and generally defines conservation as the use of methods and procedures necessary to bring a species to the
point at which the measures provided are no longer necessary. To achieve this mandate, the Oregon Fish and Wildlife Commission (Commission) exercised its authority under the OESA by adopting and implementing the Oregon Wolf Conservation and Management Plan (Wolf Plan) in 2005. The Wolf Plan requires reevaluation every five years and was last updated in 2010.

In the early stages of implementation, the Wolf Plan focused on methods and procedures to conserve wolves so that the species was self-sustaining and could be delisted. The Wolf Plan defined a population objective of four breeding pairs of wolves for three consecutive years in eastern Oregon as the guideline for when wolves may be considered for statewide delisting from OESA. Accordingly, the Wolf Plan was drafted to meet the five delisting criteria identified in Oregon Revised Statute (ORS) 496.176 and Oregon Administrative Rule (OAR) 635-100-0112.

In 1987, the USFWS completed the NRM Wolf Recovery Plan. Four years later Congress initiated an administrative process to reintroduce wolves into Yellowstone National Park and central Idaho. Extensive public input showed general support for wolf recovery, and the U.S. Secretary of Interior approved reintroduction. In 1995 and 1996, 66 wolves were captured in Alberta and British Columbia, Canada. Of those, 35 were released in central Idaho and 31 were released into Yellowstone National Park.

At the time Oregon’s Wolf Plan was first adopted in 2005, wolves were listed as endangered under the federal Endangered Species Act (ESA). To emphasize close coordination between the U.S. Fish and Wildlife Service (USFWS) and ODFW, the 2007 Federal/State Coordination Strategy for Implementation of Oregon’s Wolf Plan was developed which outlined procedures for managing wolves while federally listed. In 2007, the USFWS proposed to designate the NRM gray wolf population as a Distinct Population Segment and remove their status as endangered under federal ESA. The resulting decision to delist (and subsequent delisting decisions) was met with litigation and between 2008 and 2011 the status of NRM wolves varied between listed and delisted. In May 2011, NRM wolves, which included areas east of Highways 395-78-95 in Oregon, were delisted as a result of congressional action. Wolves in the remainder of Oregon remained listed as endangered under federal ESA (Figure 1).

Figure 1. Current Federal ESA Status of Wolves in Oregon
Table 1. Timeline of significant events in Oregon’s wolf history.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1843</td>
<td>Wolf bounty established in Oregon at the Oregon Wolf Association meeting.</td>
</tr>
<tr>
<td>1913</td>
<td>Oregon State Game Commission authorized a wolf bounty.</td>
</tr>
<tr>
<td>1946</td>
<td>Last recorded wolf submitted for bounty in Oregon from the Umpqua National Forest.</td>
</tr>
<tr>
<td>1974</td>
<td>Wolves listed as endangered in the lower 48 states under federal Endangered Species Act (ESA).</td>
</tr>
<tr>
<td>1987</td>
<td>Wolves classified as endangered in Oregon under the newly enacted Oregon ESA.</td>
</tr>
<tr>
<td>1995</td>
<td>Reintroduction of wolves by US Fish and Wildlife Service into Idaho and Yellowstone National Park. 66 wolves released over a two year period.</td>
</tr>
<tr>
<td>1999</td>
<td>First documented dispersing wolf (B45) arrived in Oregon from newly established Idaho population. Wolf was captured and returned to Idaho.</td>
</tr>
<tr>
<td>2009</td>
<td>First confirmed ‘modern’ livestock depredation (Keating wolves).</td>
</tr>
<tr>
<td>2009</td>
<td>First Oregon-collared wolf (OR1) – Keating.</td>
</tr>
<tr>
<td>2009</td>
<td>Wolves removed from federal ESA in the eastern third of Oregon as part of the Northern Rocky Mtn. Distinct Population Segment. Decision is challenged resulting in several years of relisting/delisting decisions.</td>
</tr>
<tr>
<td>2009</td>
<td>Oregon legislature reclassified wolves as a “special status game mammal”.</td>
</tr>
<tr>
<td>2009</td>
<td>First ‘modern’ lethal control action in response to chronic livestock depredation – two Keating wolves killed.</td>
</tr>
<tr>
<td>2011</td>
<td>Northern Rocky Mountain Wolves federally delisted in eastern third of Oregon as a result of congressional action.</td>
</tr>
<tr>
<td>2014</td>
<td>Phase I conservation population objective (4 breeding pairs for 3 consecutive years in eastern Oregon) is achieved.</td>
</tr>
</tbody>
</table>

Wolf Biology and Ecology

For detailed information regarding the biology and ecology of gray wolves see the Wolf Plan (Oregon Department of Fish and Wildlife 2010), or other comprehensive reviews (Verts and Carraway 1998, Mech and Boitani 2003).

Biological Status of Wolves in Oregon

Population

Successful wolf reproduction was first documented in 2008 in the northeastern portion of the state. Annual winter counts of wolves were initiated by ODFW in 2009 and Oregon’s wolf population increased in all years since (Figure 2) with a mean population growth rate of 1.43 (±
Updated information in 2015 shows that there were a minimum of 81 wolves in Oregon in 2014 (Table 2). This included 10 packs, defined as four or more wolves travelling together in winter (Oregon Department of Fish and Wildlife 2010). As of July 2015, there were 16 known groups or packs of wolves containing a male-female pair (Table 2), and the mid-year minimum population (non-pup) was 85 wolves. Oregon uses a minimum-observed count method for surveying wolves which underestimates the actual population because, 1) it does not account for all individual or non-territorial wolves which are known to occur in all wolf populations, and 2) it is unrealistic to assume complete detection of all wolves.

Figure 2. Oregon minimum wolf population 2009 - 7/2015 (2015 population does not include pups of the year)

Reproduction and pup survival

The minimum number of breeding pairs in Oregon increased since 2009 but varies annually (Table 2). Breeding pairs are considered successful if at least 2 pups survive and are documented at the end of the calendar year. In 2014, 8 of 9 Oregon breeding pairs occurred within the eastern Wolf Management Zone (WMZ) and this marks the third consecutive year in which at least 4 breeding pairs occurred in eastern Oregon; prompting entry into Phase II of the Wolf Plan. As of July 2015, we were aware of reproduction occurring in 13 packs or groups of wolves in Oregon, (the other 3 groups had not been surveyed at that time). Although these will not be considered successful breeding pairs until December 31st, they do signify a likely increase in breeding pairs for the year and this increase is consistent with past and predicted trends.

Oregon’s minimum pup counts across all years indicate a pup survival rate of 0.61 (95% CI = 0.53 - 0.69) assuming 5 pups were born per litter. This is slightly lower survival, but within the range of values reported in literature (Appendix B). Oregon’s minimum-observed count method is likely to underestimate pup survival because pups are not always together, nor are they always detected during winter surveys. See Appendix B for additional discussion of reproduction and survival rates of Oregon’s wolves.
Table 2. Oregon wolf population summary. Shaded cells denote successful breeding pairs.

<table>
<thead>
<tr>
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<tbody>
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<td>Imnaha Pack</td>
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<td>15</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>4</td>
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<td>Wenaha Pack</td>
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<td>6</td>
<td>5</td>
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<td>9</td>
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<td>Minam Pack</td>
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<td></td>
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<td>Mt Emily Pack</td>
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<td>8</td>
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<tr>
<td>Chesimimus Pair</td>
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<tr>
<td>Catherine Pair</td>
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<tr>
<td>Sled Springs Pair</td>
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<td>South Snake Wolves</td>
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<td>OR13 wolves</td>
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<td>Keno Pair</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual wolves</td>
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<td>4</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Minimum Total</strong></td>
<td><strong>14</strong></td>
<td><strong>21</strong></td>
<td><strong>29</strong></td>
<td><strong>48</strong></td>
<td><strong>64</strong></td>
<td><strong>81</strong></td>
<td><strong>85</strong></td>
</tr>
</tbody>
</table>

* Does not include pups born in 2015

** Pack and breeding pair status changed retroactively with evidence of 2014 pup production documented on March 31, 2015. The 2014 population total was also updated to reflect the new wolves.

ODFW does not routinely conduct den or rendezvous surveys in all packs/years, and relies on winter pup recruitment data to assess reproductive success. Factors affecting early pup survival in Oregon are undetermined, though canine parvovirus was responsible for the loss of pups in the Wenaha Pack in 2013 and illegal take was responsible for the loss of one pup of the Umatilla River Pack in 2013.

Distribution

Since establishment in 2008, Oregon’s wolves have expanded rapidly and wolves currently occupy 13,222 km². In July 2015, 3 new areas of known wolf activity were documented (Figure 4); 1 in south-central Oregon (OR25) and 2 in northeastern Oregon (OR22 and OR30). Currently most wolves occur within the northeastern portion of the state, and three areas of known wolf activity now occur within the southern Oregon Cascade Mountains (Figure 4).

Dispersal

ODFW has documented dispersal of 19 collared wolves from their natal territories. To date, 58% (n=11) of the dispersals terminated within Oregon and 42% (n=8) emigrated from Oregon. This observed rate of emigration was expected given proximity of wolves in northeastern Oregon to Idaho and Washington. As Oregon’s wolf population becomes more ‘interior’ the proportion of dispersers that emigrate is expected to decline. See Appendix B for more discussion on dispersal and emigration. Some dispersals are ongoing, but of completed dispersals analyzed (n=14), mean dispersal distance was 161 km.
Figure 4. Current distribution of known wolves in Oregon

Figure 5. Map of Oregon-collared wolf dispersers 2009 - 7/2015
Habitat Use and Land Ownership.

Wolves can occupy a variety of land cover types provided adequate prey exists (Keith 1983, Fuller 1989, Haight et al. 1998) and human activity is minimal (Oakleaf et al. 2006, Belongie 2008). GPS location data indicated wolves in Oregon primarily use forested habitat with seasonal shifts to more open habitats that reflect seasonal distributions of prey (e.g., lower elevation elk wintering areas). Location data from wolves collared in Oregon from 2006 to 2014 showed that 62% of all locations occurred on public and 38% on private lands (ODFW unpublished data). Denning also occurs on both public and private land in Oregon and all known den sites occurred within forested habitat. In 2015, 8 (62%) den sites were on National Forest land and 5 (38%) were on private land.

Wolf Prey

Across their range in North America, wolves depend on native large ungulates as a primary prey source (Haight et al. 1998, Fuller et al. 2003). Oregon is a multi-prey system with abundant elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), black-tailed deer (*O.h. columbianus*) and white-tailed deer (*Odocoileus virginianus*). Though prey selection may vary in multi-prey systems, diets of wolves in the NRM are dominated by elk wherever the two species co-occur (Smith et al. 2004, Oakleaf et al. 2006).

Analysis of prey selection and kill rates by wolves in Oregon has not been completed, but observations in northeastern Oregon indicate that elk are common prey species of wolves. Oregon maintains a robust and widely distributed elk population numbering an estimated 128,000 elk across 151,500 km² (ODFW data). Between 2009 and 2014, all Wildlife Management Units (WMU’s) of northeastern Oregon with established wolf packs for at least four years (Imnaha, Snake River, Walla Walla, Wenaha) had increasing elk populations, and two of the four (Imnaha and Snake River) were above the established management objectives for elk since wolves became established (ODFW data).

Other important wolf prey species include mule deer – estimated at 229,000 in eastern Oregon (ODFW data), black-tailed deer (western Oregon) and white-tailed deer (esp. northeastern Oregon). ODFW does not maintain specific population estimates of black-tailed and white-tailed deer. However, hunter harvest data shows that both species are abundant within their respective habitats. Deer distribution overlaps with all elk range in Oregon.

Diseases and Mortality of Wolves

As with most North American wildlife populations, a variety of diseases and parasites may affect wild wolf populations (Brand et al. 1995, Wobeser 2002). A thorough discussion of diseases potentially affecting wolves in Oregon is contained in the Wolf Plan (Oregon Department of Fish and Wildlife 2010).

To better understand potential exposure to several common canine diseases such as leptospirosis, canine adenovirus, canine distemper virus, and canine parvovirus, ODFW analyzed blood serum samples collected from captured wolves (n=19) between 2010 and 2013 within the Imnaha, Minam, Snake River, Umatilla River, Walla Walla and Wenaha packs (Oregon Department of Fish and Wildlife 2014). Positive parvovirus titers were found in all but 2 samples (both 4 month-old pups) and in all 6 of the packs tested. Parvovirus caused 2 instances of mortality in the
Wenaha pack in 2013 and was assigned as primary cause of the reproductive failure for that pack during that year. However, the Wenaha pack is still extant and was classified as a breeding pair in 2014 indicating transient effects of parvovirus.

Distemper virus has not been detected in the Oregon wolf population but is present throughout the state in both domestic dogs and wild canids (i.e., coyotes [Canis latrans] and foxes [Vulpes vulpes and Urocyon cineroargenteus]) and raccoons (Procyon lotor). Though distemper outbreaks have been documented in wolves in other states, it has not been a major source of mortality (Brand et al. 1995). Leptospirosis titers were also detected in 2 samples from 2 different packs and canine adenovirus titers were detected in 68% of the samples from 5 different packs (Oregon Department of Fish and Wildlife 2014). No known mortalities of wolves have been attributable to either of these diseases in Oregon.

Two important parasites in wolves are sarcoptic mange and dog-biting lice (Trichodectes canis). Sarcoptic mange is a contagious skin disease caused by a mite (Sarcoptes scabei) causing irritation and hair loss. It can lead to secondary infection and mortality of wolves (Kreeger 2003) and has been documented in NRM wolves (Jimenez et al. 2010). However, to date, mange has not been observed or suspected in Oregon wolves. Dog-biting lice can also cause hair loss and stress to wolves which may lead to reduced survival (Brand et al. 1995). Examination of more than 35 Oregon wolves and wolf carcasses between 2009 and 2015 resulted in few ectoparasites documented. Dog-biting lice were observed in one instance in 2015 on a captured wolf of the Imnaha pack, and though some hair loss was observed body condition was generally good.

Wolves are highly susceptible to human-caused mortality – evidenced by the widely accepted view that human-caused eradication efforts were responsible for the wolf’s disappearance throughout most of the contiguous United States. In Oregon, human-caused mortality including illegal take (n=5), ODFW control action (n=4), vehicle collisions (n=1), and ODFW capture-related complications (n=1) accounted for 85% of the documented wolf deaths between 2000 and present. Wolves are especially vulnerable to human-caused mortality in open habitats (Bangs et al. 2004) and since 2000, 82% (n=9) of the documented human-caused mortalities in Oregon occurred within or were associated with, open habitats. This does not imply that mortality occurred as a result of wolves utilizing open areas, but rather asserts that wolves in open habitats are likely more susceptible to control actions, management activities which may result in death, and illegal take. See Appendix B for additional discussion of the effects of anthropogenic (human-caused) mortality on wolves in Oregon.

**OESA Delisting Requirements and Analysis of Oregon Delisting Criteria**

The Wolf Plan directed wolf management activities in Oregon to achieve the conservation population objective of four breeding pairs of wolves for three consecutive years, and that once this objective was reached the process to consider removing the species from the list of endangered species under the OESA would be initiated. The conservation population objective was based on the prediction that, if the protections of the OESA cease when the objective is met, a naturally self-sustaining population of wolves would continue to exist in Oregon and this population level would support the necessary findings to justify a Commission decision to delist the species.

Oregon Revised Statute (ORS) 496.004 and Oregon Administrative Rules (OAR) 635-100-0100 defines an endangered species as “any native wildlife species determined by the Commission to
be in danger of extinction throughout any significant portion of its range within this state”. OAR 635-100-0100 to 635-100-0112 guide the Commission’s procedures and criteria for listing, delisting, and reclassifying from the list of Oregon endangered species. Furthermore, delisting a species from OESA (ORS 496.176) requires a public rulemaking decision by the Commission and this decision is to be made on the basis of scientific information and biological data. The scientific information must be documented and verifiable information related to the species’ biological status.

To delist wolves in Oregon, the Commission must evaluate the biological status of the species and determine if:

1. The species is not now (and is not likely in the foreseeable future to be) in danger of extinction in any significant portion of its range in Oregon or in danger of becoming endangered; and
2. The species’ natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human-related factors affecting its continued existence; and
3. Most populations are not undergoing imminent or active deterioration of range or primary habitat; and
4. Over-utilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is not occurring or likely to occur; and
5. Existing state or federal programs or regulations are adequate to protect the species and its habitat.

For any determination of Criterion 1 above regarding the range of a species, OAR 635-100-0105 specifies three evaluation factors to be used by the Commission:

1. The total geographic area in this state used by the species for breeding, resting, or foraging and the portion thereof in which the species is or is likely within the foreseeable future to become in danger of extinction; and
2. The nature of the species’ habitat, including any unique or distinctive characteristics of the habitat the species uses for breeding, resting, or foraging; and
3. The extent to which the species habitually uses the geographic area

Option 1
Evaluation of delisting criteria for wolves within the entire state of Oregon

Criterion 1: The species is not now (and is not likely in the foreseeable future to be) in danger of extinction throughout any significant portion of its range in Oregon or is not at risk of becoming endangered throughout any significant portion of its range in Oregon.

Within broadly defined habitat requirements described in this document, wolves are not generally known to require specific or niche habitat features within areas of use. We define and use ‘potential range’ as geographic areas of Oregon with sufficient habitat features to allow breeding, resting, and foraging requirements of wolves per OAR 635-100-0105. It does not include areas of contracted historical range (described below), nor does it provide a qualitative assessment of future wolf numbers or carrying capacity based on available habitat. A report
describing methods used for evaluating contracted historical and potential range is available in Appendix A of this document.

**Historical range**

Assessment of the baseline historical range of wolves in Oregon is difficult because: 1) historical accounts are inconsistent and often anecdotal; and 2) human-caused effects which resulted in the wolf’s extirpation pre-dated accurate surveys of the species. Historical accounts generally describe a wide distribution and variable abundance within the state (Oregon Department of Fish and Wildlife 2010), but no comprehensive surveys of wolf distribution and abundance were conducted during this period. Scientists described wolves as historically occurring in both eastern (Young 1946) and western Oregon (Bailey 1936). Bounty records up to 1946 corroborated presence of wolves from both sides of the Oregon Cascade Mountains (Olterman and Verts 1972). For this criterion, and to facilitate our analysis, we conclude that prior to European settlement most of the land area within Oregon was historical wolf range.

Historical range, however, does not mean that all geographic areas of Oregon supported sustainable sub-populations of wolves or that densities were uniformly distributed across the state. Based on preferred cover types and our current understanding of wolf ecology, some portions of Oregon historically contained areas of marginal or less suitable habitat. By example, arid and non-forested areas with low prey densities would have been expected to support few wolves (Young and Goldman 1944). In Oregon, these areas likely included much of the Columbia Basin and Great Basin rangeland habitats.

**Contraction of historical range in Oregon**

Human activities affect wolf distribution (Mladenoff et al. 1995) and the absence of wolves in human-dominated areas may reflect high anthropogenic mortality, avoidance, or both (Mech and Boitani 2003). We used human density, road density, and cultivated agriculture areas to identify geographic areas that are unsuitable for wolf establishment. We estimated permanent contraction of historical range of at least 57,889 km² (23.1%) of Oregon has occurred to date (Figure 6). A large proportion of which occurs in the Willamette Valley, where dense human population, cultivated landscape, lack of forest cover and high road density is expected to preclude significant reestablishment of resident wolves under any protection level or management policy.

**Potential range**

Several studies have assessed habitat features as related to occupancy and persistence of wolves, and though the resulting model outputs have varied, some generalizations among studies were observed. First, wolves will likely occupy areas with adequate prey populations and where conflict with humans is low (Keith 1983, Fuller 1989, Fritts et al. 2003, Carroll et al. 2006, Oakleaf et al. 2006). Second, habitat features associated with occupancy and persistence of wolves include: human density (Oakleaf et al. 2006, Belongie 2008), forest cover (Mladenoff et al. 1995, Larsen and Ripple 2004, Oakleaf et al. 2006), prey availability (Mech and Boitani 2003, Peterson and Ciucci 2003, Larsen and Ripple 2006, Oakleaf et al. 2006), public land ownership (Mladenoff et al. 1995, Carroll 2003, Mech and Boitani 2003, Larsen and Ripple 2006), and road density (Thiel 1985, Mech 1989, Carroll 2003, Carroll et al. 2006, Larsen and Ripple 2006). We are not aware of any published model which included data collected from wolves in Oregon because wolves did not occur in Oregon at the time the models were developed. We used the above factors, (sans public land ownership) and estimated the potential
range for wolves in Oregon to be approximately 106,853km$^2$, or 42.6% of the total area of the state (Figure 7). See Appendix A for a description of methods used in this analysis.

Figure 6. Estimated areas of contracted wolf range in Oregon.

Current occupied range

Wolves currently occupy 13,222 km$^2$ (12.4%) of the estimated potential wolf range in Oregon (Figure 7). Within the eastern WMZ, occupied wolf range is 31.6% of the total available area (Table 3), and in the western WMZ, occupied wolf range is 2.7% of the total available.

Table 3. Potential and Occupied Wolf Range in Oregon.

<table>
<thead>
<tr>
<th>Wolf Management Zone</th>
<th>Potential range (km$^2$)</th>
<th>Currently occupied range (km$^2$)</th>
</tr>
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<tbody>
<tr>
<td>West</td>
<td>71,011</td>
<td>1,909</td>
</tr>
<tr>
<td>East</td>
<td>35,842</td>
<td>11,313</td>
</tr>
<tr>
<td>Total</td>
<td>106,853</td>
<td>13,222</td>
</tr>
</tbody>
</table>
Extinction risk

We assessed risk of population failure or extinction of Oregon’s wolves using an individual-based population model. Specific methods and results of this analysis are presented in detail in Appendix B. The results are also summarized in Criterion 2 below.

Oregon’s wolf population is currently increasing at an annual mean rate of 1.43 (± 0.15 SD) and is projected to continue this trend in the near term. Using vital rates observed in Oregon from 2009-2014 our model had no simulations in which either the biological-extinction or conservation-failure levels were reached in the next 50 years. However, Oregon’s wolf population will transition from a rapidly increasing population to a population with lower growth
rates. The timing of this transition is unknown and to account for this we modeled the wolf population using conservative inputs, and the resulting analysis indicated a low (5%) probability of wolves dropping below 4 breeding pairs or fewer within the next 50 years and the risk of the population becoming biologically extinct (i.e., < 5 wolves) was about 1% over the same time period. The modeled risk of extinction was reduced even further in our analysis when using an initial population (100 or more) larger than the current minimum wolf population (n = 85). However, as discussed elsewhere in this document, initial population size used in our model was based on observed minimum counts and the actual population is likely larger. Even using conservative biological inputs over the long term, our modeled wolf population is projected to continue to increase at a mean growth rate of 1.07 (± .17 SD).

Summary conclusions for Criterion 1

We evaluated a combination of historical, potential, and currently occupied wolf range in Oregon to evaluate Criterion 1. In addition, we identified portions of the state which have been altered by humans in a manner that preclude current and future use by wolves. These contracted range areas are not likely to affect the threat of extinction of the species in Oregon because 1) they represent a relatively small portion of Oregon’s available wolf habitat, and 2) the biological requirements of wolves indicate that some of these now unsuitable areas were likely marginal or unsuitable year-round habitats anyway.

Though wolves continue to increase in both distribution and abundance, they currently occupy a relatively small portion (12.4%) of the estimated potential wolf range in Oregon. This disparity is especially prevalent in the western WMZ in which approximately 3% of the potential range is currently occupied by wolves. However, representation in two distinct and separate geographical portions of the state (Figure 7) is an indication that conditions exist (e.g., habitat capability, connectivity, and prey availability) to support wolves in both the east and west WMZ’s. Successful range expansion of a species is often used as a measure of population fitness, and there are no known conditions which prevent wolves from occupying currently unoccupied areas of potential wolf range.

The eventuality that wolves would become established in the eastern WMZ before the western WMZ was accurately predicted by the Commission when the 2005 Oregon Wolf Plan was adopted. The decision to divide the state into two WMZ’s was an intentional effort to provide the flexibility needed to manage increasing numbers of wolves in eastern Oregon while maintaining conservation measures for colonizing sub-populations in western Oregon. When evaluating the threat of extinction in Oregon’s potential and current wolf range we considered that: 1) wolves were once extirpated as a result of historical efforts to eradicate them, and now in absence of those efforts and under current management frameworks, are increasing in abundance and distribution; 2) there are no known conditions which prevent wolves from inhabiting currently unoccupied portions of range in Oregon; 3) observed movement and dispersal patterns indicate connectivity from source populations; and 4) the probability of extinction in Oregon is low (see Criterion 2 below).

Criterion 2: The species’ natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human-related factors affecting its continued existence.

To assess the risk of population failure in Oregon wolves, we conducted a population viability analysis (PVA) using an individual-based model which incorporated 6 demographic processes
(in order): 1) survival between age classes; 2) emigration from Oregon; 3) territory establishment by dispersing wolves; 4) immigration into Oregon; 5) anthropogenic mortality; and 6) reproduction. Initial model inputs using conservative vital rate estimates allowed us to err on the side of caution and prevent overly optimistic conclusions regarding viability. In our model, any simulated population which drops below the Wolf Plan’s conservation objective of four breeding pairs was considered a conservation-failure. Any simulated population that dropped below 5 wolves was considered biologically extinct. The full analysis is described in Appendix B of this report, and the results are summarized as follows:

1. The current population growth rate for Oregon wolves is 1.43 (± 0.15 SD), and this growth is projected to continue in the near term.
2. Based on conservative model inputs, Oregon’s modeled wolf population over time is projected to increase at a minimum mean population growth rate of 1.07 (±.17 SD).
3. Using conservative input parameters, we estimated a 5% probability of the population reaching the conservation-failure threshold (< 4 breeding pairs), and 1% probability of biological extinction over the next 50 years. Most of the simulated conservation-failures occurred within the first 10 years of simulation.
4. Our model used a starting population of 85 wolves. Increasing the starting population to 100 reduced the risk of conservation-failure to 1%.
5. Using vital rates required to match population growth rates of wolves in Oregon from 2009-2014 resulted in no simulations reaching the conservation-failure threshold; an indication of conservative model inputs.
6. Factors which had the most influence on model outputs were related to survival (of pups and adults), human-caused mortality, litter size, frequency of catastrophic reductions in survival and reproduction, and starting population size.
7. Human-caused mortality was treated as additive to natural survival (i.e., 1-natural mortality rate × human-caused mortality) in our model and the probability of conservation-failure was low (0.05) when applying human-caused mortality rates of 0.1 or less. These findings are based on the current starting population of 85 wolves, and larger populations will likely be able to sustain higher human-caused mortality rates.

Disease

Disease-related mortality of young wolves can affect the population in two ways: 1) direct population reduction; and 2) reduced ability of the population to expand or re-colonize new areas. Canine parvovirus and distemper are two diseases commonly observed in wolf populations that typically cause temporary and local effects on wolf populations and are not expected to affect long term viability (Bailey et al. 1995, Brand et al. 1995, Kreeger 2003). However, high pup mortality to parvovirus may slow colonization of new areas (Mech et al. 2008). Though wolves in Oregon are commonly seropositive for parvovirus, only two mortalities to parvovirus (1 adult and 1 yearling, 2013) have been documented in a single pack (Wenaha), and this pack remains extant and productive (Oregon Department of Fish and Wildlife 2015). These observations suggest presence of disease is having minimal effects on wolf survival or reproductive success in Oregon. Furthermore Oregon’s wolf population continues to colonize new areas despite the presence of disease, and we contend disease has not been a significant factor in Oregon’s wolf population to date.

The population effect of sarcoptic mange and dog-biting lice (Trichodectes canis) is not affecting viability of wolves in Oregon. Mange can affect pup survival, and its occurrence may be positively correlated with higher wolf densities (Brand et al. 1995). Though it has been detected
in the NRM wolves east of the Continental Divide (Jimenez et al. 2010), it has not been observed in Oregon and likely will have little effect on wolf populations in the near term. The single instance of dog-biting lice observed in 2015 indicates a low occurrence that may be related to increased densities of wolves in northeast Oregon; however, no mortality has been documented as a result.

Because Oregon has recorded very little disease-caused mortality, we assessed the influence of disease on wolf viability by including two effects into our PVA: 1) range-wide reductions in survival at random intervals; and 2) pack-specific complete reproductive failure at random intervals. The latter was intended to simulate situations (such as parvovirus outbreak) in which all pups born in a single litter die in a given year. Overall this had minimal effects on our results so long as intervals between reproductive failures within a pack were greater than once every 10 litters – well below rates currently observed in Oregon (1 out of 20). Potential effects of disease as incorporated in our model had the greatest effect when wolf populations were small and the effects decreased as simulated wolf populations became larger. These model results combined with minimal observed occurrences suggest disease is not a significant threat to wolves in Oregon.

**Predation:**

In general, few interactions between wolves, bears and cougars have been recorded (Jimenez et al. 2008) and no predators are known which routinely prey on wolves (Ballard et al. 2003). In addition, since monitoring began in 2009, ODFW has not documented predation of wolves by other predators.

Within wolf populations, intra-specific mortality may be the largest cause of predation and this may be highest in dense wolf populations (Mech and Boitani 2003). However, in Oregon no intra-specific mortality has been observed, and though it likely has occurred at some level, we do not consider it to be a population limiting factor and account for this mortality in our analysis (via. annual survival parameter inputs).

**Other natural or human-related factors**

As described elsewhere in this document, data shows that dispersing wolves immigrate (how they first arrived into the state) and emigrate from Oregon, indicating that Oregon is part of a larger meta-population with Idaho. Genetic sampling of captured Oregon wolves (ODFW, unpublished data) confirms genetic relatedness to the Idaho subpopulation of wolves, further indicating a biological connection between the two subpopulations. Because of this, our population analysis includes parameters for immigration and emigration and assumes that both will continue.

At the time the Wolf Plan was first adopted, the ability of wolves to reach areas of habitat outside of northeast Oregon was assumed but undocumented. However, habitat connectivity between the eastern and western WMZ’s has since been confirmed by two radio-collared wolves (OR7 and OR25), and further indicated by at least four uncollared adult wolves in the southern Oregon Cascade Mountains. Recently breeding wolves were documented in northern California (California Department of Fish and Game News Release August 20, 2015), and though the genetic source of these wolves is unknown at the time of this report, it is expected that these wolves are likely connected to Oregon or other NRM wolves.
Data from GPS-collared dispersers shows that dispersal in Oregon occurred largely through forested habitats. However, dispersers which travelled more than 85 km generally crossed a variety of land cover types and landscape features (i.e., open prairie or shrub habitats, roads, rivers, etc.). To evaluate effects of major highways as barriers to dispersal, we examined crossings of two interstate highways by dispersing wolves fitted with GPS collars; Interstate 84 in eastern Oregon and Interstate 5 in western Oregon. Seven collared wolves in Oregon are known to have crossed Interstate 84, and one wolf (OR7) crossed Interstate 5 on two occasions. We documented fourteen instances where GPS-collared wolves crossed interstate highways in Oregon, with four wolves (OR7, OR14, OR24, and OR30) crossing more than once. Data from two GPS-collared dispersers (OR15 and OR18) indicate attempted, but unsuccessful crossings of Interstate 84 in 2014 between La Grande and Pendleton. In both cases the wolves changed dispersal course and ultimately emigrated from Oregon. It is notable that both of these emigrating dispersers were from Oregon’s most remote pack (Snake River) and prior to dispersal had few encounters with busy roadways and vehicles. Oregon’s only documented highway-related mortality was in May 2000 when a wolf dispersing from Idaho was struck by a vehicle on Interstate 84 south of Baker City. Combined, these observations of dispersing wolves suggest interstate highways are at least partially permeable and do not prevent dispersal of wolves.

The ability for wolves to cross large rivers is also important for maintaining connectivity between Oregon wolves and the larger NRM meta-population which includes Idaho. To date, we have no data of wolves crossing the Columbia River. Wolves in Oregon are genetically related to wolves in Idaho, and GPS-collared dispersers in Oregon have successfully crossed the Snake River 14 times. This apparent ease of large river crossing is consistent with collar data from non-dispersing wolves of the Snake River pack (a shared Oregon/Idaho pack) which in 2013 showed regular crossings of the Snake River (ODFW, unpublished data). These crossings indicate the river itself does not impede connectivity between subpopulations in Idaho and Oregon.

Genetic viability is a critical concern for any threatened or endangered population (Frankham et al. 2002, Scribner et al. 2006). Small populations of wolves are unlikely to be threatened by low genetic diversity (Boitani 2003). Although inbreeding is a potential threat to the long-term viability for small and isolated populations (Liberg 2005, Fredrickson et al. 2007), there are examples of wolf populations which are small and isolated which have persisted for decades (Fritts and Carbyn 1995, Boitani 2003, Liberg 2005). Regarding a ‘required’ population size, Fritts and Carbyn (1995) stated the following:

“Most theoretical analyses of population viability have assumed a single, isolated population and lack of management intervention, neither of which is likely for wolves. Data on survival of actual wolf populations suggest greater resiliency than is indicated by theory. In our view, the previous theoretical treatments of population viability have not been appropriate to wolves, have contributed little to their conservation, and have created unnecessary dilemmas for wolf recovery programs by overstating the required population size”

Genetic interchange between subpopulations is important to maintain genetic health of any wildlife population and as few as 1-2 immigrants per generation (~5 years with wolves) is generally considered sufficient to minimize effects of inbreeding (Vila et al. 2003, Liberg 2005). This requirement is easily attained because wolves have the demonstrated ability to rapidly disperse long distances and avoid inbreeding by selecting unrelated mates (Vonholdt et al. 2008). Montana and Idaho wolf population are connected to each other and to Canada through natural dispersal (U. S. Department of the Interior 2009), and Oregon wolves are genetically related to Idaho wolves. For example, Oregon’s westernmost wolf pack (Rogue) in the southern Oregon
Cascade Mountains is only 1 generation removed from central Idaho wolves – the breeding male of that pack (OR7) is an offspring of an Idaho-born female (B300). We contend that high levels of genetic diversity in Oregon wolves will be maintained through connectivity to the larger NRM wolf population. Natural dispersal will allow a sufficient number of immigrants to arrive in Oregon so long as sufficient connectivity is maintained between populations in adjacent states (Hebblewhite et al. 2010).

As a source population, the genetic health of the NRM reintroduced wolves is also important to understanding the genetic health of Oregon wolves. Wolves reintroduced into Idaho in 1995 and 1996 originated from two distinct wolf populations in Canada – 15 wolves from 7 packs came from Hinton, Alberta in 1995, and 20 wolves from 9 packs came from Fort St. John, British Columbia in 1996 (M. Jimenez, USFWS, personal communication). Subsequent genetic analysis concluded that the reintroduced wolves were as diverse as their general source population (Forbes and Boyd 1996;1997) and that genetic variation within the NRM is high (Forbes and Boyd 1996;1997, Vonholdt et al. 2008). While our analysis of wolf-population viability did not explicitly incorporate genetic effects, we recognize that genetic effects could become important if the Oregon wolf population becomes isolated from the remainder of the NRM wolf population.

The challenges of wolves in areas with livestock are well documented, and wolves prey on domestic animals in all parts of the world where the two coexist (Mech and Boitani 2003). From 2009 through June 2015, wolf depredation in Oregon resulted in confirmed losses of 79 sheep, 37 cattle, 2 goats, and 2 livestock protection dogs. Management of wolf-livestock conflict utilizes a three-phased approach based on population objectives and emphasizes non-lethal measures while increasing management flexibilities as the wolf population increases (Oregon Department of Fish and Wildlife 2010). In all phases of implementation the Wolf Plan requires that non-lethal techniques remain the first choice of managers when addressing wolf-livestock conflicts. Currently, we are implementing Phase II of the Wolf Plan in the eastern WMZ and OAR 635-110-0020 outlines conditions for legal harassment and take of wolves in response to wolf-livestock conflict in the federally delisted portion of the eastern WMZ. The total incidence of livestock depredation is expected to increase as Oregon’s wolf population increases and expands their geographic range. However, we have no data indicating whether the proportional rate of depredation will increase or decrease.

In all areas where wolves occur with people, some wolves are killed (Fritts et al. 2003), and human-caused mortality was responsible for the initial extirpation of wolves from Oregon. There are many references which relate human tolerance to successful wolf management (Mech 1995, Bangs et al. 2004, Smith 2013), and for our analysis we consider that the primary human-related impacts to wolves are realized through direct human-caused mortality.

The Wolf Plan (and associated rules) outlines conditions for when human-caused mortality is authorized. In the federally delisted portion of the eastern WMZ, OAR 635-110-0020 is currently in effect regardless of OESA listing status, and this rule allows human take for wolf-livestock conflict under the following: 1) take of wolves caught in the act of attacking or chasing livestock; and 2) agency take of wolves in response to chronic livestock depredation. To date, no wolves have been killed while attacking or chasing livestock in Oregon. Since 2009, four wolves have been lethally removed by ODFW in response to chronic depredation of livestock. We expect that total lethal take of wolves in response to wolf-livestock conflict will increase as the wolf population increases, but we have no indication of whether proportional lethal take of wolves will change.
Other sources of human-mortality include capture-related loss, incidental take loss, accidental take, and illegal take. To date, we have documented one capture-related death in Oregon (OR8 in 2011) in which a wolf died following aerial capture. Four wolves have been incidentally captured in Oregon by trappers targeting other animals, but all were released unharmed and no mortalities as a result of incidental capture have been documented. Accidental loss is documented by one vehicle collision in 2000 in eastern Oregon. Five wolves are known to have been illegally killed (all shot) in Oregon since 2000. We consider that under current and near-future regulatory and management mechanisms, and regardless of state and federal listing status, total incidental, accidental, and illegal losses will increase as Oregon’s wolf population increases, however, we expect losses to remain proportionally similar. In addition, we acknowledge that documented losses to date necessarily represent minimums and that the actual loss may be higher.

Using baseline parameter estimates in our PVA, Oregon’s wolf population is projected to increase if total human-caused mortality, as implemented in our PVA, is initially kept below 0.10 (<10 wolves during first year). From 2009-2014, human-caused mortality did not exceed this figure, and though human-caused mortality could increase under implementation of current Phase II rules, we have no information suggesting human-caused mortality it will exceed 0.10. Further, because at least a portion of human-caused mortality is regulated by ODFW, the agency could presumably control this level of mortality so that it does not exceed this amount.

The Wolf Plan sets a management population objective of seven breeding pairs for three consecutive years in eastern Oregon, and this is referred to as Phase III. Based on current population figures described elsewhere in this document, Oregon could enter into Phase III as early as 2017. In Phase III, controlled take of wolves may be permitted as a management tool if the wolf population objectives have been exceeded and other biological considerations indicate that it would not affect wolf viability in the region. In this situation, controlled take could only be authorized as a response to: 1) chronic livestock depredation problems in a localized region; or 2) wild ungulate population declines (below management objective levels) that can be attributed to wolf predation. Though it is difficult to predict the number of wolves removed through controlled take, at least a portion of controlled take which could occur in Phase III may likely replace other types of agency take (in federally delisted portions of Oregon only) – especially take related to chronic livestock depredation. In addition, our analysis shows increasing population resilience to human-caused losses as the wolf population increases to Phase III levels. Because of these two factors and within the findings of our population analysis we contend that the effect of human-caused mortality related to Phase III of the Wolf Plan will not affect the future viability of wolves in Oregon.

Summary Conclusions for Criterion 2

Oregon’s known wolf population is relatively small but increasing in both distribution and abundance. Using population growth rates observed from 2009-2014, our simulation results indicated wolves had no risk of conservation-failure or biological-extinction over the next 50 years. Using biological conservative input parameters resulted in an estimated mean population growth rate of 1.07 with a probability of conservation failure (i.e., dropping below 4 breeding-pairs) of 5% and a biological extinction (i.e., dropping below 5 wolves) probability of 1% over the next 50 years. Most of the simulated conservation failures occurred in the first 10 years when the simulated wolf population was small. Increasing the modeled starting population to 100 wolves reduced the probability of conservation failure to 1%.
Observed occurrence of disease and predation in Oregon has been low. We accounted for these types of mortality in our analysis and we have no information suggesting that either factor will limit population growth or affect the future viability of the species in Oregon. Other factors considered important for wolves in Oregon are connectivity of habitats and management of forested areas. Oregon is part of a larger meta-population of wolves which includes Idaho, and we identified no landscape features which prevent dispersing wolves from immigrating to or emigrating from Oregon. Furthermore, the ability of dispersing wolves to colonize available habitat in western Oregon has been confirmed. Given the wolf’s generalized habitat requirements, forest conditions are not expected to change on a large scale or in a manner to affect habitat suitability for wolves.

The genetic health of NRM wolves is high. In context of a larger meta-population, Oregon’s wolf population is neither small, nor isolated. It follows that the genetic variation of Oregon wolves is also high. Our dispersal data shows immigration and emigration of wolves, a clear indication that Oregon’s wolf population is biologically connected to other sub-populations of wolves within in the NRM area, and is expected to continue to exchange genetic diversity over time.

Human-caused mortality rates included in our PVA, which are higher than currently observed in Oregon, didn’t cause a significant risk of conservation failure or biological extinction. Based on existing management/regulatory guidelines and regardless of listing status, future rates of human-caused mortality are not likely to exceed those rates used in our PVA/population model.

**Criterion 3: Most populations are not undergoing imminent or active deterioration of range or primary habitat.**

Wolves were extirpated from Oregon as a result of direct eradication effort, but have undergone active expansion of range within Oregon since the natural re-establishment of wolves in 2008.

In 2009, two wolf territories occupied an area of 1,440 km$^2$ in northeastern Oregon. In 2014, 15 wolf territories covered an estimated 12,582 km$^2$ in two distinctly separate geographic regions of the state; northeastern Oregon and the southern Oregon Cascades (Figure 7).

Not all of Oregon’s historical range is available to wolves and in addressing Criterion 1 we estimated portions of Oregon which because of high human densities, extensive road systems, and cultivated habitats, are no longer suitable for wolves regardless of protection and management policies in place (see contracted range discussion above, Figure 6). Oregon’s human population is currently estimated at 3.9 million people (Source: US Census Bureau), has increased 12% over the past 10 years, and is projected to reach 4.8 million people by 2030 (Source: 2014 World Population Review). We do not expect significant additional contraction of wolf range because much of Oregon’s human population (and projected growth) is concentrated in the Willamette Valley, where range is already contracted due to conversion of habitat to agriculture. Furthermore, outside of currently developed areas, much of Oregon’s geography is unsuitable for major settlement by humans.

Though wolves may use a variety of habitats, a strong relationship between persistence of wolf populations and forested cover has been established (Mladenoff et al. 1995, Larsen and Ripple 2006, Oakleaf et al. 2006). Approximately 50% of Oregon is public land with a large portion managed as forested habitat. Both state and federal forests are regulated in Oregon – National Forests are regulated by federal law and multiple-use forest plans, and state and private forests
under Oregon forest protection laws and regulations. We are not aware of any planned or imminent changes in laws or policies affecting Oregon’s forest management on a broad scale. We expect that forest attributes and conditions which allowed Oregon’s wolf population to increase and expand to its present distribution, will continue in the foreseeable future.

Our analysis of potential range in Oregon did not include a metric for assessing habitat quality or effects of habitat on wolf density. However, an additional recognized definition of wolf habitat suitability is an area with sufficient food resources to support reproduction (Carroll, 2006). In Oregon, wolf prey populations (i.e., deer and elk) are widely distributed across the state and most populations are robust. Because prey population declines have not been observed to date in areas longest occupied by wolves, and deer and elk management is highly regulated under other state plans, we do not foresee near-term reductions in prey populations.

Summary conclusion for Criterion 3

Wolves are expanding their range in Oregon and therefore cannot be undergoing active deterioration of range. With the availability of widespread and publicly owned forested areas, and policies/laws in place to prevent depletion of both private and public forest, we cannot foresee imminent deterioration of important wolf habitats. Though Oregon’s human population will increase, most growth will occur in already altered or unsuitable habitats for wolves.

Criterion 4: Over-utilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is not occurring or likely to occur.

Prior to federal ESA protections, gray wolves were killed for a number of reasons which included commercial use of the pelts and other parts. Historically, illegal commercial trafficking in wolf pelts or parts occurred in the U.S., but the degree to which it occurred in Oregon is unknown. The potential for prosecution for take provided by federal ESA and state regulations has likely discouraged and will continue to discourage killing of wolves for commercial or recreational purposes.

Illegal capture of wolves for commercial breeding purposes may also occur or may have occurred in Oregon, but we consider this unlikely. Under existing rules wolves in Oregon may not be legally killed or removed from the wild for commercial, recreational, or educational purposes regardless of listed status. Federal prohibitions (with criminal penalties) are in place that prohibits killing, taking, disturbing, trade and possession of wolves in areas where the federal ESA continues to apply in the state (i.e., west of Hwys 395-78-95).

Wildlife is managed in Oregon under the Oregon Wildlife Policy (ORS 496.012) which states in part: “wildlife shall be managed to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state.” In 2009 the Oregon Legislative Assembly changed the status of wolves from “protected non-game wildlife” to “special status game mammal” under ORS 496.004 (9). The classification recognizes the wolf’s distinct history of extirpation and conflict with certain human activities. Under this classification, and when in Phase III of the Wolf Plan, controlled take of wolves could be permitted only after wolf population objectives have been exceeded and other biological considerations indicate controlled take would not affect viability of the wolf population. Controlled take could be authorized as a response to chronic livestock depredation in a localized region where wolf populations are self-sustaining, or in response to reduced
recruitment or declines of any wild ungulate populations below management objectives in a WMU that can be attributed to wolf predation.

Delisting gray wolves from protection from the OESA would not result in or allow any additional commercial, recreational, scientific, or educational activities except as provided by the Commission by permit.

ODFW may not authorize incidental take where the wolf is protected by the federal ESA, but incidental take has been authorized (OAR 635-100-0170(1) and 653-110) in Oregon for USDA, APHIS - Wildlife Services in federally delisted portions of the state from 2010 to present. Under this permit, in 2012 one wolf was incidentally taken (trapped) by a Wildlife Services agent and released unharmed. And in 2013 when three wolves were incidentally trapped by licensed trappers and released unharmed (Oregon Department of Fish and Wildlife 2014).

Per the Wolf Plan, ODFW and its collaborators will continue to capture and radio-collar wolves for monitoring and research purposes. To date, ODFW has conducted 42 wolf captures in Oregon, with a per wolf capture-caused mortality of 2.4% (2011, post-capture mortality of one wolf). Oregon uses rigorous wolf capture protocols to ensure the well-being of wolves, and personnel involved with wolf capture are specifically trained. Because of this, we expect that capture-caused mortality by federal and state agencies and universities conducting wolf monitoring, nonlethal control, and research will remain low (<5% percent of the wolves captured), and will be an insignificant source of mortality to the wolf population.

ODFW is not aware of any wolves that have been legally removed from the wild for educational purposes. Division 044 administrative rules make it unlawful for keeping pure-bred gray wolves in captivity for education, breeding or sale except for a limited number of education facilities licensed by U.S. Department of Agriculture. Wolves that are used for such purposes are usually the captive-reared offspring of wolves that were already in captivity for other reasons.

There is a growing public interest in wildlife viewing and ecotourism in Oregon and across the U.S. When carefully planned and implemented, fish and wildlife-based tourism can promote fish and wildlife conservation through public outreach and support; diversity to local economies; and provide rewarding experiences for a variety of people. In Oregon, 1.4 million residents and nonresidents participate in wildlife viewing. Viewing wolves on public lands is largely compatible with wolf conservation, provided that it does not disturb sensitive den and rendezvous sites. ODFW will continue to work with federal partners to ensure wolf safety, management compatibility and visitor enjoyment. Wolf-based tourism has proven to be highly profitable in and around Yellowstone National Park and elsewhere (Wilson and Heberlein 1996, Wilson 1997, Montag et al. 2005).

Wolves are strongly associated with forested habitats, but are generally recognized as habitat generalists. As discussed in Criterion 3 above, management of both public and private forest lands are highly regulated in Oregon. Wolves are increasing and expanding under Oregon’s current forest management policies and we have no information which indicates that current utilization of forests is negatively affecting the wolf population.
Summary conclusion for Criterion 4

Current statutory classification and specific wolf policy in Oregon is adequate to prevent overutilization of wolves in any management phase of the Wolf Plan. We have no information indicating overutilization of gray wolves or their habitat for commercial, recreational, scientific, or educational purposes is occurring or likely to occur in Oregon.

Criterion 5. Existing state or federal programs or regulations are adequate to protect the species and its habitat.

The following summarizes current and future protection programs and regulations for wolves in Oregon. Appendix C of this document contains a list of statutes and technical administrative rules pertaining to this section.

State Protection

Wolves are currently protected throughout Oregon by the OESA. The OESA generally prohibits ‘take’ of wolves by persons anywhere in the state (ORS 498.026). Take is defined by ORS 496.004(16) as killing or obtaining possession or control. In 2013, the Oregon Legislature increased take flexibilities for livestock producers in situations where wolves, if federally delisted, are caught in the act of biting wounding, killing, or chasing livestock in certain situations (HB3452, 2013 Oregon Legislative Assembly). The provisions of the 2013 legislative action are contained within 635-110 rules referenced below. See Appendix D in the Wolf Plan (Oregon Department of Fish and Wildlife 2010) for statutory protections and authorities afforded wolves while listed under OESA.

Regardless of OESA listing status, wolves are managed under the Phase II of the Wolf Plan (Oregon Department of Fish and Wildlife 2010) and associated technical administrative rules (Division 110) which govern harassment and take of wolves in federally delisted portions of Oregon. In Phase II, management activities are directed toward achieving the management population objective of seven breeding pairs of wolves present in eastern Oregon for three consecutive years. This phase also provides a buffer whereby management actions do not allow declines which could lead to relisting under the OESA. Phase II is currently in effect in eastern Oregon, these protections and regulations would not change following delisting.

The Wolf Plan sets a management population objective of seven breeding pairs for three consecutive years in eastern Oregon, and this is referred to as Phase III. Based on current population figures described elsewhere in this document, eastern Oregon could enter into Phase III as early as 2017. In Phase III, controlled take of wolves may be permitted as a management tool if the wolf population objectives have been exceeded and other biological considerations indicate that it would not affect wolf viability in the region. In this situation, controlled take would only be authorized as a response to: 1) chronic livestock depredation problems in a localized region; or 2) wild ungulate population declines (below management objective levels) that can be attributed to wolf predation. As discussed above (Criterion 2), the expected level of human-caused mortality related to Phase III of the Wolf Plan will not negatively affect the future viability of wolves in Oregon.

The Wolf Plan is incorporated in Division 110 administrative rules by reference. On July 12, 2013, the Commission adopted amendments to OAR 635-110-0010 and 635-110-0020 which
regulates harassment and take of wolves during Phase I and Phase II of the Wolf Plan, respectively. OAR 635-044-0051 governs the holding of pure-bred wolves in Oregon. The rules makes it unlawful for keeping pure-bred gray wolves in captivity for education, breeding or sale except for a limited number of education facilities licensed by the U.S. Department of Agriculture. ORS 498.026 makes transactions in threatened or endangered wildlife species unlawful. No person shall take or attempt to take, import, export, transport, purchase, or sell any threatened or endangered species or the skin, hides, or other parts.

The Wolf Plan calls for periodic evaluation with the next scheduled evaluation set to begin in 2016. The results of any evaluation may result in rulemaking by the Commission to change or revise the Wolf Plan. At this time there are no planned recommendations from ODFW which would weaken protections for wolves to a level which would threaten future population viability.

Federal Protection

On May 5, 2011, the USFWS published a final rule – as directed by Congressional legislative language in the enacted Fiscal Year 2011 appropriations bill – reinstating the Service’s 2009 decision to delist biologically recovered gray wolf populations in the NRM, including a portion of Oregon. Wolves in Oregon located west of Highways 395-78-95 remain protected by the federal ESA. The USFWS is the lead management agency for wolves that occur west of Highways 395-78-95 and all provisions of the federal ESA apply.

All actions regarding harassment and take of wolves in federally listed portion of Oregon are governed by the USFWS. This includes a portion of the eastern WMZ currently in Phase II of the Wolf Plan (Figure 8).

Figure 8. Federal status within Oregon’s East and West Wolf Management Zones.
Incidental take has been authorized (OAR 635-100-0170(1) and 653-110-0040) in Oregon for USDA APHIS-Wildlife Services. ODFW issued Wildlife Services an Incidental Take Permit (ITP) from 2010 to the present, and in 2012 one wolf was incidentally taken (trapped) and released unharmed. ODFW may not issue ITPs where the wolf is protected by the federal ESA. Three other situations of incidental take have occurred in Oregon. In 2013, three wolves were incidentally trapped by licensed trappers, and in all three cases the wolves were released unharmed (Oregon Department of Fish and Wildlife 2014).

In 2009, Oregon Legislative Assembly changed the status of wolves from “protected non-game wildlife to “special status game mammal” under ORS 496.004 (9). The classification recognizes the wolf’s distinct history of extirpation and conflict with certain significant human activities. Under this classification, and when in Phase III of the Wolf Plan, controlled take of wolves would be permitted as a management response tool to assist ODFW in its wildlife management efforts only after the wolf population objectives in the region to be affected have been exceeded and other biological considerations indicate the use of these management tools would not result in the impairment of wolf viability in the region.

Summary conclusion for Criterion 5

The combination of programs and regulations listed above have proved adequate as conservation measures by allowing wolves which entered Oregon to become established and ultimately increase to their present levels. The Wolf Plan and associated rules currently in place will continue to be followed regardless of OESA listing status, and we contend these protections are adequate and comprehensive to allow wolf populations to continue to increase in Oregon. Specifically, protections and provisions currently associated with Phase II of the Wolf Plan will be in place before and after delisting. Wolves are managed in Oregon under the state wildlife
policy (ORS 496.012) and though the Wolf Plan is scheduled to be evaluated in 2016, we do not anticipate significant changes that would threaten the future viability of wolves in Oregon.

**Effects of a Delisting Decision by Commission**

A delisting decision by the Commission is not expected to significantly affect the management of wolves. This is because the Wolf Plan and associated OAR’s guide the management of wolves regardless of OESA listing status, and a delisting decision would not inherently alter the management aspects of the Wolf Plan. Wolves within the eastern WMZ are currently managed under Phase II of the Wolf Plan until the Phase III objectives are met, and wolves in the western WMZ are managed under Phase I until the Phase II objectives are met.

A decision to delist wolves would have no effect on the federal classification status, and wolves outside of the NRM Distinct Population Segment (all portions of Oregon west of Highways 395-78-95) are federally listed as endangered. All harassment and take of wolves in the federally listed portion of Oregon is regulated by the USFWS.

The Wolf Plan requires reevaluation on a five year interval, with the next evaluation scheduled to begin in 2016. The Commission could enter into rulemaking to amend or change the Wolf Plan as a result of any evaluation. Specifically, rules and provisions regarding protection, harassment, and take of federally delisted wolves could be changed. We anticipate that the scheduled upcoming plan evaluation will be completed prior to the end of 2016.

Wolves within the eastern WMZ could enter into Phase III as early as 2017. In Phase III, controlled take of wolves may be permitted as a management response tool if wolf population objectives have been exceeded and other biological considerations indicate that it would not affect wolf viability in the region. In this situation, controlled take would be authorized as a response to: 1) chronic livestock depredation problems in a localized region; or 2) wild ungulate population declines (below management objective levels) that can be attributed to wolf predation. Though not specifically defined, any authorized take of wolves in Phase III assumes wolves are delisted from OESA.

While a delisting decision by the Commission will not otherwise affect decisions related to harassment or take of wolves in Oregon, it may have social implications. Indeed the Commission’s decision to divide the state into two wolf management zones was a tacit effort to provide the flexibility needed to manage increasing numbers of wolves in eastern Oregon while maintaining conservation in western Oregon. This approach was intended to promote social tolerance for wolves by effectively addressing conflict with competing human values through the use of management measures consistent with long-term wolf conservation in all phases of wolf management.

**Conclusion**

As predicted when the Wolf Plan was developed, wolves have become established in Oregon and have increased in both distribution and abundance from 2008 through 2014. Our analysis of future population growth using conservative parameter inputs indicates a very high probability that Oregon’s wolf population will grow and remain extant in future years. There is a low probability of decline below conservation levels, and most of our simulated failures occurred
within the first 10 years of simulation when the population is lowest. Based on observed population growth rates in Oregon the wolf population should surpass 100 to 150 individuals in the next 1-3 years regardless of listed status, and the risk of conservation failure is even further reduced. Factors related to wolf health, habitat, dispersal, habitat connectivity, and wolf survival all indicate a healthy and growing population that is unlikely to decline in the near-term.

Wolves still occupy a relatively small portion of the estimated potential range in Oregon. However, they are represented within both east and west WMZ’s and there are no known conditions which prevent wolves from occupying much of the currently unoccupied areas of range. This situation was accurately predicted by the Commission when the 2005 Oregon Wolf Plan was adopted and the decision to divide the state into two management zones was a tacit effort to provide the flexibility needed to manage increasing numbers of wolves in eastern Oregon while maintaining conservation measures for colonizing sub-populations in western Oregon. Our evaluation of the threat of extinction in Oregon’s potential and current wolf range we determined that: 1) wolves were once extirpated as a result of historical efforts to eradicate them, and now in absence of those efforts and under current management frameworks, are increasing in abundance and distribution; 2) there are no known conditions, which prevent wolves from inhabiting currently unoccupied portions of range in Oregon; 3) observed movement and dispersal patterns indicate connectivity from source populations and 4) the probability of population failure in Oregon is very low.
Option 2:

Evaluation of delisting criteria specifically for wolves within the eastern Oregon Wolf Management Zone

Note: This section is added at the direction of the Oregon Fish and Wildlife Commission on April 24, 2015. Because most of Oregon’s wolves occur within the eastern WMZ, most of the biological information contained in Part 1 of this analysis is directly applicable here. In this analysis we present biological and scientific information which is specific to evaluation of delisting criteria within the eastern WMZ. Appendix B (page 33) contains an additional section related specifically to population viability of wolves within the eastern WMZ in Oregon.

Biological Status of Wolves in the Eastern WMZ

The wolf population has increased within the eastern WMZ at a mean growth rate of 1.40 (± 0.18 SD) since 2009. In July, 2015 the non-pup wolf population was 76 known wolves (Table 4). Eight successful breeding pairs of wolves were documented within the eastern WMZ in 2014 and this was the third consecutive year in which at least 4 successful breeding pairs of wolves were documented in this zone (Table 4). All factors influencing reproduction, survival, dispersal, distribution, and disease are outlined in Part 1 of this document.

Table 4. Eastern WMZ wolf population. Shaded cells denote successful breeding pairs.

<table>
<thead>
<tr>
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<td></td>
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<td>5</td>
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<tr>
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<td></td>
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<td></td>
<td>2</td>
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<td>2</td>
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<td>Chesnimmusus Pair</td>
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<tr>
<td>Catherine Pair</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
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<td>South Snake Wolves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6**</td>
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<td>OR13 wolves</td>
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<td></td>
<td></td>
<td></td>
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<td>Individual wolves</td>
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</tr>
<tr>
<td>Minimum Total</td>
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<td>21</td>
<td>29</td>
<td>48</td>
<td>63</td>
<td>74</td>
<td>76</td>
</tr>
</tbody>
</table>

Criterion 1; eastern WMZ: The species is not now (and is not likely in the foreseeable future to be) in danger of extinction throughout any significant portion of its range in Oregon or is not at risk of becoming endangered throughout any significant portion of its range in Oregon.
Appendix A contains a report describing methods used for evaluating historic, contracted, and potential range for wolves in Oregon, including the eastern WMZ. Currently, wolves occupy 31.6% of potential wolf range within the eastern WMZ (11,313 km² out of 35,842 km² of potential range).

Figure 8. Current distribution of known wolves within the eastern WMZ

We assessed risk of population failure or extinction of Oregon’s wolves using an individual-based population model. Methods and results of this analysis are presented in detail in Appendix B. Specifically; an eastern WMZ analysis is contained on Page 33 of that report. The results are also summarized in Criterion 2 below.

Using conservative parameter inputs, our analysis indicated a low (6%) probability of wolves dropping below 4 breeding pairs or fewer within the next 50 years. None of our simulations resulted in the population becoming biologically extinct (i.e., < 5 wolves) over the same time period. The modeled risk of extinction was reduced even further in our analysis when using an initial population (100 or more) larger than the current minimum wolf population. However, as discussed elsewhere in this document, initial population size used in the model was based on observed minimum counts and the actual population is likely larger. Based on conservative parameter inputs, the eastern WMZ wolf population is projected to increase at a mean annual population growth rate of 1.06 (± 0.17 SD).

Conclusion for Criterion 1; eastern WMZ

Wolves continue to increase in both distribution and abundance and occupy a significant portion (31.6%) of the estimated potential wolf range in the eastern WMZ. Conditions exist (e.g., habitat capability, connectivity, and prey availability) to support wolves throughout the zone.
Successful range expansion of a species is one measure of population fitness, and there are no known conditions which prevent wolves from colonizing currently unoccupied areas of range within the eastern WMZ.

**Criterion 2; eastern WMZ:** The species’ natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human-related factors affecting its continued existence.

To assess the risk of population failure in Oregon wolves specifically within the eastern WMZ, we used our existing model (Appendix B) to assess viability of wolves. In this analysis, we restricted our starting population size to those wolves known to occur in the eastern WMZ as of April 1, 2015 \( (N = 76) \) and set the density threshold to 600 wolves compared to 1,500 wolves used in the statewide analysis. Remaining methods and parameter inputs for this analysis were identical to those used in the statewide assessment of wolf population viability. As with the statewide analysis, we used two metrics to assess population viability: 1) conservation-failure, defined as the population dropping below 4 breeding pairs and 2) biological-extinction, defined as the population having fewer than 5 individuals. The following summarizes the results of that analysis.

1. The eastern WMZ modeled wolf population is projected to increase at a mean population growth rate of 1.06 \( (\pm 0.17 \text{ SD}) \)
2. Using conservative input parameters, we estimated a 6% probability of the population reaching the conservation-failure threshold \( (< 4 \text{ breeding pairs}) \). Half of the simulated conservation-failures occurred within the first 10 years of simulation.
3. No simulated populations dropped below the biological-extinction threshold over the next 50 years.
4. Risk of conservation-failure in the eastern WMZ was slightly higher, but not significantly different, than risk at a statewide level \( (0.06 \text{ vs. } 0.05) \)

**Conclusion for Criterion 2; eastern WMZ**

Risk of conservation-failure in the eastern WMZ was slightly higher, but not significantly different, than risk at a statewide level \( (0.06 \text{ vs. } 0.05) \). Our results suggested that risk of conservation-failure declined with increasing starting population size, so it was not surprising that the slightly smaller starting population in the eastern WMZ \( (N = 76) \) had a slightly higher risk of conservation-failure compared to the statewide population \( (N = 85) \).

**Criterion 3; eastern WMZ:** Most populations are not undergoing imminent or active deterioration of range or primary habitat.

Similar to the statewide analysis, wolves in the eastern WMZ have expanded their range rapidly. Since 2009 the area occupied by known wolves has increased by approximately 1,975 km\(^2\) per year and wolves currently occupy approximately 11,313 km\(^2\) within northeastern Oregon (Appendix A). As summarized in Part 1, we are not aware of any planned or imminent changes in laws or policies affecting Oregon’s forest management on a broad scale. We expect that forest attributes and conditions which allowed Oregon’s wolf population to increase and expand to its present distribution, will continue in the foreseeable future.
Conclusion for Criterion 3; eastern WMZ

As they are statewide, wolves are expanding their range in the eastern WMZ of Oregon and therefore cannot be undergoing active deterioration of range. With the availability of widespread and publicly owned forested areas, and policies/laws in place to prevent depletion of both private and public forest, we cannot foresee imminent deterioration of important wolf habitats. Though Oregon’s human population will increase, most growth will occur in areas already altered or unsuitable habitats for wolves.

**Criterion 4; eastern WMZ: Over-utilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is not occurring or likely to occur.**

For this criterion there are no factors specific to the eastern WMZ which differ from the statewide analysis presented earlier in Part 1of this document.

**Criterion 5; eastern WMZ. Existing state or federal programs or regulations are adequate to protect the species and its habitat.**

For this criterion there are no significant differences between the eastern WMZ analysis and the statewide analysis. All known and resident wolves within the eastern WMZ which are the basis of this evaluation are currently within the federally delisted portion of Oregon, and the regulatory mechanisms presented in Part 1 of this document apply entirely.

Effects of an Eastern WMZ Delisting Decision by the Commission

A delisting decision by the Commission is not expected to affect the management of wolves within the eastern WMZ. This is because the Wolf Plan and associated OAR’s guide the management of wolves regardless of OESA listing status, and a delisting decision by the Commission would not inherently alter the management aspects of the Wolf Plan. Wolves within the eastern Oregon WMZ are currently managed under Phase II of the Wolf Plan until the Phase III objectives are met.

A decision to delist wolves would have no effect on the federal classification status, and wolves outside of the NRM Distinct Population Segment (all portions of Oregon west of Highways 395-78-95) are federally listed as endangered. All harassment and take of wolves in the federally listed portion of Oregon is regulated by the USFWS.

The Wolf Plan requires reevaluation on a five year interval, with the next evaluation scheduled to begin in 2016. The Commission could enter into rulemaking to amend or change the Wolf Plan as a result of any evaluation. Specifically, rules and provisions regarding protection, harassment, and take of federally delisted wolves could be changed. However, this evaluation is based only on the management strategies and protective mechanisms contained within the current Wolf Plan.

Wolves within the eastern WMZ could enter into Phase III as early as 2017. In Phase III, controlled take of wolves may be permitted as a management response tool if wolf population objectives have been exceeded and other biological considerations indicate that it would not affect wolf viability in the region. In this situation, controlled take would be authorized as a
response to: 1) chronic livestock depredation problems in a localized region; or 2) wild ungulate population declines (below management objective levels) that can be attributed to wolf predation. Though not specifically defined, full implementation of Phase III assumes wolves are delisted from OESA.

Conclusion

As predicted when the Wolf Plan was developed, wolves have become established within the eastern WMZ and have increased in both distribution and abundance from 2008 through 2014. Our analysis of future population growth using conservative parameter inputs indicates a very high probability that the eastern WMZ population will remain extant in future years. In our analysis there is a low probability of decline below conservation levels. Based on observed population growth rates in the eastern WMZ, and the current year’s observations the wolf population will likely surpass 100 individuals in 2015 and the risk of conservation failure is even further reduced. Factors related to population fitness (e.g., wolf health, habitat, dispersal, habitat connectivity, and wolf survival) all indicate a healthy and growing population that is unlikely to decline in the near-term.

Wolves occupy a significant portion of the estimated potential range within the eastern WMZ and there are no known conditions which prevent wolves from occupying much of the currently unoccupied areas of range. When evaluating the threat of extinction in Oregon’s potential and current wolf range we considered that: 1) wolves were once extirpated as a result of historical efforts to eradicate them, and now in absence of those efforts and under current management frameworks, are increasing in abundance and distribution; 2) there are no known conditions, which prevent wolves from inhabiting currently unoccupied portions of range within the eastern WMZ; 3) observed movement and dispersal patterns indicate connectivity from source populations and 4) the probability of extinction in Oregon is very low.
Option 3

Analysis of a no-action decision by the Commission

If the Commission takes no action with regard to delisting, wolves in Oregon will simply remain listed as endangered under the OESA. In general, this will have few biological implications for wolves in Oregon for many of the same reasons given above. The following is a brief summary analysis of the effects of a no-action decision by the Commission as related to the five delisting criteria above.

Criterion 1 – the species is not now (and is not likely in the foreseeable future to be) in danger of extinction in any significant portion of its range in Oregon or in danger of becoming endangered. Wolves will continue to increase and expand. The current observed rate of annual increase is $1.43 \pm 0.15$SD and this is expected to continue in the near years. Our long-term projected rate of annual increase is $1.07 \pm 0.17$SD but is based on conservative parameter inputs moving forward. We have no data to suggest that the continued listing of wolves as endangered would improve their long-term viability, projected population growth rate, or continued range expansion. This is because under the Wolf Plan, wolves are given identical protections whether listed or delisted and our population model indicated wolves are capable of long-term persistence and population growth under these conditions. At the point in the future that delisting is reconsidered, our population trend and viability analysis shows there will simply be more wolves in more areas of Oregon, and this will occur whether the species is delisted or not.

Criterion 2 – the species’ natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human-related factors affecting its continued existence. Our population trend and viability analysis shows that if wolves are considered for delisting in the future, the population will be higher, more dispersed, and will have a lower probability of conservation-failure or extinction. Our analysis shows that wolf populations are likely to increase regardless of OESA listing status and risk of population or reproductive failure declines with larger “starting” populations. Oregon’s wolf population will likely surpass 100 animals in 2015, and at this population size using our population model, risk of population or reproductive failure is almost eliminated. Therefore, reductions of population viability risk gained by continued listing under OESA are nominal.

If the Commission deems that the biological criteria are met, a no-action decision may have the effect of eroding general support for the Wolf Plan and thereby reducing public tolerance for wolves. Though it is nearly impossible to predict or enumerate a biological effect, a reduction of public tolerance may be manifested through increased take (both illegal and authorized take) of wolves. It cannot be ignored that it was lack of public tolerance for wolves which led to the wolf’s original extirpation. The importance of anthropogenic mortality is the primary factor that influences dynamics in most wolf populations and our model shows that at current rates of both legal and illegal anthropogenic mortality the population will continue to grow. However, if those rates are increased to sustained high levels (e.g., .20) the population would be expected to decline.

Criterion 3 – most populations are not undergoing imminent or active deterioration of range or primary habitat. A no-action decision is not expected to affect the condition of range or primary habitat for wolves because wolves continue to expand their range into potential habitat
in Oregon, and we identified no factors specifically related to the current listed status of wolves which would affect future expansion or deterioration of range.

Criterion 4 – over-utilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is not occurring or likely to occur. Statutory classification of wolves in Oregon allows protection from over-utilization regardless of listing status – there are no additional opportunities for recreational, scientific, or educational purposes if wolves were delisted. Thus, a no-action decision would not be expected to change these levels of utilization.

Criterion 5 – existing state or federal programs or regulations are adequate to protect the species and its habitat. The combination of statutory classification (i.e., special status game mammal) and the Wolf Plan and its associated rules, provide an adequate regulatory framework regardless of listing status. Because neither will change significantly as a result of delisting, a no-action decision is unlikely to affect the protection status of wolves. For example, damages assessed under ORS 496.705 for unlawful taking of wolves’ remains the same for listed or delisted wolves.

Conclusion

A no-action decision by the Commission will likely have nominal biological effects on Oregon’s wolf population. This is because our analysis shows that wolves will continue to increase in Oregon under a listed or a delisted OESA status, and the probability of wolves dropping to currently defined conservation levels is very low. However, continued support for the Wolf Plan is important for the management of wolves and public tolerance for wolves is an important outcome of plan implementation. Though it is unknown at this time the level to which public tolerance for wolves might decrease as a result of a no-action decision, any loss of support or tolerance may negatively affect wolves in the future.
Literature Cited


Bailey, V. 1936. The mammals and lifezones of Oregon. Pages 416 in North American Fauna


Young, S. B. 1946. The Wolf in North American History. in The Caxton Printers, LTD, Caldwell, ID.

Appendix A

Mapping Potential Gray Wolf Range in Oregon

This updated report is presented as Appendix A to the Oregon Fish and Wildlife Commission as part of the 2015 Biological status review for the gray wolf in Oregon and evaluation of criteria to remove the gray wolf from the List of Endangered Species under the Oregon Endangered Species Act.

Presented: October 9th, 2015

Suggested citation:
Oregon Department of Fish and Wildlife. 2015. Updated mapping potential gray wolf range in Oregon. Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Drive SE. Salem, OR 97302.
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INTRODUCTION AND METHODS

As part of a biological status review of gray wolves (*Canis lupus*) in Oregon, we developed a map of potential wolf range in Oregon and calculated the amount of potential range currently occupied by wolves. To develop our map of potential wolf range, we used landscape predictor variables similar to Larsen and Ripple (2006) who predicted wolf abundance and distribution in Oregon from wolf data collected in other states. Our approach was to create a simple 1-category map at a course resolution (1 km²), indicating where wolves could potentially occur in Oregon. The 5 main predictors of wolf habitat from previous research are 1) forested areas (Mladenoff et al. 1995, Larsen and Ripple 2006, Oakleaf et al. 2006, Benson et al. 2015), 2) public ownership (Mladenoff et al. 1995, Carroll et al. 2003, Larsen and Ripple 2006), 3) prey availability (Mech and Peterson 2003, Peterson and Ciucci 2003, Larsen and Ripple 2006, Oakleaf et al. 2006), 4) low human presence (Belongie 2008), and 5) low road density (Mech et al. 1988, Kohn et al. 2001, Carroll et al. 2003, Larsen and Ripple 2006, Belongie 2008, Zimmermann et al. 2014, Benson et al. 2015). We used all these predictors for Oregon, except public ownership, because data from Oregon indicate that wolves use both private and public lands with forested cover. Our mapping process included extracting and merging spatial data related to land cover type, elk ranges, human population density, road density, cultivated or other land types altered by humans. A short description of each data source and steps used to develop a potential wolf range map follows.

Potential Wolf Range

*Forested Areas* – We obtained land cover data for Oregon from the National Land Cover Database (NLCD, Jin et al. 2013). We generalized the original data set from a 0.09 km² resolution to 1.0 km² resolution (1000-m x 1000-m cell size). We then extracted land cover types identified as forested (Fig. 1). We buffered these forested areas by 2,000 meters to include forest edge habitats that we expect are used by wolves.
Figure 1. Distribution of forested land cover types, generalized to a 1 km² resolution, in Oregon. Data obtained from the National Land Cover database.

Elk Ranges – The second step of our analysis accounted for prey availability. Where elk and wolves coexist, elk serve as the primary prey for wolves (Mech and Peterson 2003). Consequently, we used elk range maps (Fig. 2, ODFW and Rocky Mountain Elk Foundation, unpublished data) as a surrogate for prey availability. We did not account for deer ranges in our analysis because deer are present in all elk ranges. Furthermore, we did not account for quality of deer and elk habitat or abundances of deer and elk within defined range boundaries. We overlaid elk ranges with our map of forested areas, keeping only areas where both forested areas and elk range overlapped. The subsequent map was retained for further analysis.
Figure 2. Boundaries of elk range in Oregon. Data were obtained from maps developed by the Oregon Department of Fish and Wildlife and Rocky Mountain Elk Foundation.
**Contracted Range**

Once we identified potential wolf range we then identified “contracted range”, areas no longer available to wolves because they are dominated by human habitation, roads, or agriculture.

**Human Population** – We obtained human population information from U. S. Census block data (Oregon Geospatial Enterprise Office 2015) and we calculated human density across Oregon. We extracted areas with human densities > 4 humans / km$^2$ (Belongie 2008) and we applied a buffer of 1600-m around these areas.

**Road Density** - We calculated road density from publically available data (Bureau of Land Management 2015). We used areas of known wolf activity (AKWA) in Oregon to estimate a threshold value of road density above which wolves did not currently occur. Our analysis suggested wolves did not currently occur in areas where road densities exceeded 3.5 km of road/ km$^2$.

**Developed, cultivated, and pasture lands** – We extracted land types from the NLCD layer identified as developed, cultivated, or hay/pasture and we applied a buffer of 1,000 meters around these areas.

We combined all the above described areas that were impacted by human activities to identify contracted range. In total, contracted range represented approximately 23.1% (57,889 km$^2$) of the total land area in Oregon (Fig. 3).

**Contiguous Potential Range**

After removing areas of contracted range, we then removed contiguous areas of potential range < 500 km$^2$, which was the mean territory size of wolf packs in the Greater Yellowstone Ecosystem (Carroll et al. 2003). We took this approach to remove small, isolated patches of potential range that would not be capable of supporting a pack of wolves. In Oregon, mean territory size of 13 wolf packs determined from GPS locations was 1,030 km$^2$. Consequently, our final map of potential wolf range (Fig. 4) is conservative because it includes areas of potential range smaller than the currently observed territory sizes of wolves in Oregon.
Figure 3. Distribution of contracted range, separated by human activities that prevent the area from being classified as potential wolf range.
RESULTS AND SUMMARY

Our mapping process identified 106,853 km² of potential wolf range in Oregon (Fig. 4; Table 1). Overlaying AKWAs with our potential range map suggested our map corresponded well with known wolf distributions (Fig. 5). The exception is an area used by the Imnaha and Chesnimmus packs in northeast Oregon, whose AKWAs encompasses a large area of non-forested habitat known as the Zumwalt Prairie. This area is a remnant prairie which is productive and remote enough to support large elk herds in a non-forested environment. However, this habitat type is not present in significant amounts elsewhere in Oregon.

Figure 4. Distribution of potential wolf range in Oregon as determined by spatial analysis conducted by Oregon Department of Fish and Wildlife.
Figure 5. Current distribution of areas of known wolf activity compared to potential wolf range in Oregon.
Table 1. Summary of area of potential wolf range by wolf management zone in Oregon and amount of potential range currently occupied by wolves.

<table>
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<th>Management zone</th>
<th>Potential range (km$^2$)</th>
<th>Currently occupied range (km$^2$)</th>
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<tr>
<td>West</td>
<td>71,011</td>
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</tr>
<tr>
<td>East</td>
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<td>11,313</td>
</tr>
<tr>
<td>Total</td>
<td>106,853</td>
<td>13,222</td>
</tr>
</tbody>
</table>

Our map of potential wolf range indicates more potential range occurs in the west management zone (71,011 km$^2$) than the east management zone (35,842 km$^2$). Currently, wolves occupy 31.6% of potential wolf range in the east management zone (11,313 km$^2$ out of 35,842 km$^2$ of potential range; Fig. 6). In contrast, wolves currently occupy approximately 2.7% of potential range in the west management zone (1,909 km$^2$ out of 71,011 km$^2$ of potential range).
Figure 6. Potential wolf range by wolf management zone and currently occupied potential range in Oregon.
LITERATURE CITED


Appendix B

Assessment of Population Viability of Wolves in Oregon

This technical report to the Oregon Fish and Wildlife Commission presents results from an updated individual-based population model used to assess population viability of wolves in Oregon. The model uses wolf data collected in Oregon through July 2015.

Presented: October 9th, 2015

Suggested citation:
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**Executive Summary**

We present results from an individual-based population model (IBM) used to assess the viability of the gray wolf (*Canis lupus*; hereafter, wolf) population in Oregon. When parameterizing our model, we relied heavily on published estimates of wolf vital rates. We compared estimates of parameters used in our model to those observed in Oregon from 2009-2014 and concluded our model used to project future population growth was conservative compared to growth rates currently observed in Oregon. We used a starting population size of 85 wolves which was based on wolf population counts conducted by the Oregon Department of Fish and Wildlife (ODFW) through July 2015. This value is higher than reported end of year counts (ODFW 2015) because additional wolves that were present in Oregon at the start of the biological year (i.e., April) were documented after January 31, 2015. Consequently, results presented in this report differ slightly from those presented to the Oregon Fish and Wildlife Commission on April 24, 2015. We used linear regression models to determine the relative effect of model parameters on intrinsic population growth rates of wolves. We assessed population viability using two metrics: 1) the cumulative proportion of simulations that had fewer than 4 breeding pairs (defined as conservation-failure) and 2) the cumulative proportion of simulations that had fewer than 5 wolves (defined as biological-extinction).

Increased pup ($\beta = 0.045$), yearling ($\beta = 0.024$), and adult ($\beta = 0.019$) survival resulted in increased population growth rates. Population growth rates of wolves were most sensitive to environmental stochasticity, which we modeled through the use of a prey multiplier ($\beta = 0.088$). The increased environmental stochasticity incorporated in the model by the prey multiplier increased variation in survival rates of wolves by up to 20% annually, which caused this parameter to have a large effect on population growth rates. Increased levels of illegal ($\beta = -0.027$) and legal ($\beta = -0.028$) anthropogenic mortality had negative effects on population growth rates. Increased mean litter size had a positive effect on population growth ($\beta = 0.049$).

Increased mortality rates for dispersing wolves had a negative effect on population growth ($\beta = -0.026$) while increased probabilities of dispersing wolves successfully establishing a territory had a positive effect on population growth ($\beta = 0.034$). Combined, these results highlight the importance of survival, reproduction, and human-caused mortality on population growth rates of wolves. Other parameters considered in our model had minimal effects on population growth rates or viability of wolves. Maintenance of high natural survival and reproductive rates of wolves while minimizing human-caused mortality will help ensure the long-term persistence of the species in Oregon.

Our baseline model indicated there was a 0.05 (95% CI = 0.01 – 0.09) probability of wolves falling below the conservation-failure threshold and a 0.01 (95% CI = 0.00 – 0.03) probability of falling below the biological-extinction threshold in the next 50 years. When we parameterized our model with vital rates required to match population growth rates observed in Oregon from 2009-2014, we did not observe any situations where the simulated wolf population fell below the conservation-failure or biological-extinction thresholds. Consequently, we contend future risk of conservation-failure falls between estimates from our baseline model (0.05 probability of conservation-failure) and our model parameterized with vital rates required to match observed population growth rates of Oregon’s wolves from 2009-2014 (0.00 probability of conservation-failure). Regardless of model parameterization, our results suggested it is extremely unlikely wolves in Oregon will be at risk of extirpation over the next 50 years.
INTRODUCTION

The Oregon Wolf Conservation and Management Plan (hereafter, Oregon Wolf Plan; Oregon Department of Fish and Wildlife [ODFW] 2010) outlines phases of wolf (*Canis lupus*) recovery and criteria for delisting wolves as required by Oregon’s Endangered Species Act (ESA). In January 2015, Oregon’s wolf population successfully reached population objectives for Phase I to allow ODFW to propose that the Oregon Fish and Wildlife Commission consider delisting of wolves from Oregon’s ESA (ODFW 2010). Quantitative models are commonly used to assess population dynamics and extinction risk of threatened and endangered species (Boyce 1992, Morris and Doak 2002) and can provide insight into the first and second delisting criteria outlined in the Oregon ESA:

1. “The species is not now (and is not likely in the foreseeable future to be) in danger of extinction in any significant portion of its range in Oregon or in danger of becoming endangered”; and
2. “The species natural reproductive potential is not in danger of failure due to limited population numbers, disease, predation, or other natural or human related factors affecting its continued existence”.

To address these delisting criteria, we developed a quantitative model to provide insight into dynamics of Oregon’s wolf population to help inform any future decisions regarding wolves and Oregon’s ESA.

To make accurate predictions of future population growth, quantitative population models should accurately reflect biological processes of the species being modeled. Individual-based models (IBM) were previously used to model wolf population dynamics (Vucetich et al. 1997, Haight et al. 1998, Nilsen et al. 2007, Bull et al. 2009) because they can most accurately represent the unique social and breeding structure of wolf populations. We modified an IBM developed to assess effects of management on wolf populations in Norway (Bull et al. 2009) to meet our needs to assess population viability of wolves in Oregon. Our modeling approach focused on determining effects of key biological processes, uncertainty in model parameters, and management actions on wolf population dynamics and viability.

METHODS

We used an IBM modified from Bull et al. (2009) to assess future population dynamics of wolves in Oregon. Our model incorporated 6 demographic processes that affected wolf populations that were modeled in the following order (Fig. 1): 1) survival and transition between age classes, 2) dispersal and emigration out of Oregon, 3) territory establishment by dispersing wolves, 4) immigration from outside Oregon, 5) anthropogenic mortality, and 6) reproduction. Our IBM included 5 distinct social classifications of wolves (Fig. 2) and transitions between social classifications were governed by distinct model parameters (Table 1).

Our IBM was coded and implemented in R (R Development Core Team 2012). To generate our results, we conducted 100 realizations of population growth over 50 years. We incorporated environmental stochasticity in our model by randomly drawing vital rate values from a uniform distribution with a predefined mean and standard deviation at each time step of the simulation (Table 1). Unless otherwise noted, vital rates were applied at an individual level, which inherently incorporated demographic stochasticity into our model. For each simulated population we tracked parameter values, population size and growth rates, and number of breeding pairs (i.e., pairs of wolves with \( \geq 2 \) pups surviving the biological year) at each time step.
Figure 1. The order in which 6 key demographic processes are implemented in an individual-based population model to assess population viability of wolves in Oregon.

Figure 2. Visual representation of the life cycle of wolves implemented in an individual-based population model to assess population viability of wolves in Oregon. The diagram represents probabilities of transitions between age- and social-classes of wolves. Parameters used in transition calculations are defined in Table 1.
Table 1. Parameter values used to predict future population growth of wolves in Oregon compared to values required to match observed growth rates of Oregon's wolf population from 2010-2014. Values used at each time step of the analysis were randomly drawn from a uniform distribution within the specified standard deviation (SD). Mean values are probabilities unless otherwise stated.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Baseline model values</th>
<th>Values required to match growth rates observed in Oregon (2009-2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pup survival rate</td>
<td>$S_p$</td>
<td>0.68 0.15</td>
<td>0.75 0.05</td>
</tr>
<tr>
<td>Yearling survival rate</td>
<td>$S_y$</td>
<td>0.81 0.06</td>
<td>0.91 0.04</td>
</tr>
<tr>
<td>Adult (2 to 7-yrs old) survival rate</td>
<td>$S_{ad}$</td>
<td>0.88 0.04</td>
<td>0.91 0.04</td>
</tr>
<tr>
<td>Old adult (8 to 9-yrs old) survival rate</td>
<td>$S_{old}$</td>
<td>0.63 0.11</td>
<td>0.85 0.05</td>
</tr>
<tr>
<td>Pup dispersal rate</td>
<td>$D_p$</td>
<td>0.15 0.05</td>
<td>0.15 0.05</td>
</tr>
<tr>
<td>Yearling dispersal rate</td>
<td>$D_y$</td>
<td>0.65 0.05</td>
<td>0.65 0.05</td>
</tr>
<tr>
<td>Non-breeding adult dispersal rate</td>
<td>$D_{ad}$</td>
<td>0.65 0.05</td>
<td>0.65 0.05</td>
</tr>
<tr>
<td>Proportion of dispersing wolves that survive</td>
<td>$M_d$</td>
<td>0.90 0.05</td>
<td>0.97 0.02</td>
</tr>
<tr>
<td>Proportion of dispersing wolves that leave Oregon</td>
<td>$E_d$</td>
<td>0.115 0.03</td>
<td>0.115 0.03</td>
</tr>
<tr>
<td>Probability of dispersing wolf establishing a territory</td>
<td>$T$</td>
<td>0.75 0.10</td>
<td>0.75 0.10</td>
</tr>
<tr>
<td>No. of immigrants arriving annually from outside Oregon</td>
<td>$I$</td>
<td>3 2</td>
<td>3 2</td>
</tr>
<tr>
<td>Pregnancy rate for dominant females</td>
<td>$P_{ad}$</td>
<td>0.95 0.02</td>
<td>0.95 0.02</td>
</tr>
<tr>
<td>Litter size</td>
<td>$L$</td>
<td>5 3</td>
<td>5 3</td>
</tr>
<tr>
<td>Proportion of wolves removed by illegal mortality</td>
<td>$IM$</td>
<td>0.05 0.03</td>
<td>0.02 0.01</td>
</tr>
<tr>
<td>Proportion of wolves removed by legal mortality</td>
<td>$LM$</td>
<td>0.05 0.03</td>
<td>NA NA</td>
</tr>
<tr>
<td>Prey index multiplier (adjustment to survival rates)</td>
<td>$Pr$</td>
<td>1.00 0.10</td>
<td>1.00 0.10</td>
</tr>
<tr>
<td>Density dependent threshold (no. of wolves)</td>
<td>$CC$</td>
<td>1,500 NA</td>
<td>1,500 NA</td>
</tr>
<tr>
<td>Probability of population wide reduction in survival</td>
<td>$S_{cas}$</td>
<td>0.01 NA</td>
<td>NA NA</td>
</tr>
<tr>
<td>Probability of pack-specific reproductive failure</td>
<td>$R_{cas}$</td>
<td>0.05 NA</td>
<td>0.05 NA</td>
</tr>
</tbody>
</table>
Model Parameters

Currently, Oregon has minimal vital rate information to parameterize a population model, and the potential for sampling bias or error from small sample sizes (i.e., observed data does not match the expected outcome) could cause inappropriate conclusions to be reached by using this information. Furthermore, estimated vital rates from protected wolf populations that are colonizing or recovering are unlikely to match those of established wolf populations (Ballard et al. 1987, Hayes and Harestad 2000, Fuller et al. 2003). Oregon’s wolf population is transitioning from a recovering to established population. Vital rates used in our IBM were obtained primarily from studies conducted in established wolf populations. Consequently, whenever possible, we compared vital rates obtained in Oregon to those reported in literature to determine the degree to which vital rates used in our model were representative of those observed in Oregon since 2009. In general, most vital rates used in our baseline model were conservative compared to those observed in Oregon from 2009-2014. Using conservative vital rate estimates allowed us to err on the side of caution (e.g., the precautionary principle; Myers 1993, Meffe et al. 2006) and prevent overly optimistic conclusions of wolf population viability.

Starting Population Size.—We utilized minimum count data collected by ODFW to determine our starting population size and structure prior to wolves producing pups in April. These counts were higher than final survey numbers reported at the end of 2014 (ODFW 2015) because ODFW identified additional wolves after the report was submitted. Based on wolf survey information collected through July 2015, a minimum of 85 wolves were present in Oregon at the start of April. We acknowledge additional, undocumented wolves may be present in Oregon, but we relied on known individuals when developing our model. Counts identified 16 pairs or packs of wolves in addition to 3 individual wolves present in Oregon. Whenever possible, we used known data to assign pack, age, social class, and sex of wolves and randomly assigned these attributes when unknown. Newly documented pairs of wolves were assumed to consist of a male and female and both individuals were assigned dominant-adult status.

Survival.—Baseline survival rates of wolves used in our model represented survival in the absence of anthropogenic mortality (e.g., poaching, management removals). We adjusted survival rates reported in literature to account for anthropogenic mortality using the following approach: 1) determine the overall mortality rate (1 – survival rate), 2) estimate the anthropogenic mortality rate as the product of proportion of total mortalities caused by humans and the overall mortality rate, and 3) sum the estimated anthropogenic mortality rate and the reported survival rate. As an example, Smith et al. (2010) reported an annual survival rate of 0.750 with 54% of mortality attributable to legal or illegal actions by humans. The anthropogenic mortality rate was 0.135 (1-0.750 × 0.540), which resulted in a ‘natural’ survival rate of 0.885 (0.750 + 0.135). In instances where authors directly reported cause-specific mortality rates (e.g., Wydeven et al. 1995), we summed reported survival and anthropogenic mortality rates to obtain an adjusted estimate of survival. After adjusting survival rates reported in literature (Table 2) we arrived at a survival rate of 0.88 (± 0.04 SD) of adult wolves (2-7 years old; S_{ad}) for use in our model.

Using the largest sample size of radio-collared wolves reported in published literature, Smith et al. (2010) reported that yearling wolves had a 54.9% higher risk (1.0012^{365} = 1.549) of mortality than adult wolves over 365 days. We adjusted the mean survival rate of 0.88 for adult (2-7 years) wolves by the increased hazard rate reported by Smith et al. (2010) to calculate a survival rate of 0.81 for yearling wolves (S_{y}; 1-[(1-0.88) × 1.549]; Table 1). This may present an overly pessimistic view of resident yearling wolf survival, because yearlings have high
dispersal rates (Gese and Mech 1991) and dispersing wolves were found to have higher risk of mortality (Smith et al. 2010). In our model, we utilized a separate mechanism to account for increased mortality of dispersing wolves (see below) and we recognize our estimates of yearling survival may be negatively biased. Senescence, observed through decreased survival at older ages is common for large mammals (Loison et al. 1999, Gaillard et al. 2000, Clark et al. 2014), but this phenomenon is not well documented in wolves. To account for the potential of senescence, we used an annual survival rate for wolves > 7 years old of 0.63 as reported Cubaynes et al. (2014), which we adjusted to 0.67 for use in our model (S_{old}) to account for anthropogenic mortality. Wolves ≥ 10 years of age had a survival rate of 0.00 in our model. While free-ranging wolves can live longer than 10 years, most wolves are typically no longer reproductively active after this age (Fuller et al. 2003, Kreeger 2003) and will contribute little to population growth and viability.

Estimates of non-pup survival used in our model were lower than observed to date in Oregon. Using known-fate survival analysis (White and Burnham 1999) on a sample 23 of wolves radio-collared in Oregon from 2009-2014, we estimated an annual survival rate of wolves > 6 months old of 0.91. Three collared wolves died during this timeframe, one of which was removed by ODFW and an additional wolf was illegally shot resulting in 66% of mortality being attributable to humans. Adjusting survival rates to account for anthropogenic mortality results in a survival rate of 0.97, which is substantially greater than the adult (0.88) and yearling (0.81) survival rates used in our model.

<table>
<thead>
<tr>
<th>Source</th>
<th>Reported survival</th>
<th>Human-caused mortality rate</th>
<th>Adjusted survival rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams et al. (2008)</td>
<td>0.79</td>
<td>0.09^b</td>
<td>0.89</td>
</tr>
<tr>
<td>Cubaynes et al. (2014)</td>
<td>0.80</td>
<td>0.04^c</td>
<td>0.84</td>
</tr>
<tr>
<td>Fuller (1989)</td>
<td>0.62</td>
<td>0.26^c</td>
<td>0.88</td>
</tr>
<tr>
<td>Hayes and Harestead (2000)</td>
<td>0.84</td>
<td>0.02^b</td>
<td>0.86</td>
</tr>
<tr>
<td>Peterson et al. (1984)</td>
<td>0.67</td>
<td>0.26^b</td>
<td>0.93</td>
</tr>
<tr>
<td>Smith et al. (2010)</td>
<td>0.75</td>
<td>0.14^b</td>
<td>0.89</td>
</tr>
<tr>
<td>Webb et al. (2011)^d</td>
<td>0.62</td>
<td>0.34^b</td>
<td>0.96</td>
</tr>
<tr>
<td>Wydeven et al. (1995)</td>
<td>0.61</td>
<td>0.28^b</td>
<td>0.89</td>
</tr>
<tr>
<td>Wydeven et al. (1995)</td>
<td>0.82</td>
<td>0.04^b</td>
<td>0.86</td>
</tr>
<tr>
<td>Mean</td>
<td>0.72</td>
<td>0.16</td>
<td>0.88</td>
</tr>
</tbody>
</table>

^a Sum of reported survival and human-caused mortality rate.
^b Mortality rate calculated as the product of overall mortality rate (1-survival) and proportion of mortalities caused by humans.
^c Human-caused mortality rate directly reported by authors.
^d Apparent survival rates estimated from mark-recapture data.

Table 2. Annual survival rates and human-caused mortality rates of non-pup wolves reported in literature. Survival rates were estimated from known fates of radio-collared wolves unless otherwise noted. Adjusted survival rates represent survival rates on non-pups in the absence of human-caused mortality.
Estimates of survival of wolf pups from birth to 6 months are highly variable and are usually estimated by comparing pup counts at den or rendezvous sites to in utero fetal counts of harvested females. Based on a review of literature (Table 3), we determined mean survival rates of wolf pups from birth to 6 months, determined from pup counts, were 0.73. Estimation of survival using pup count data assumes that pups are counted with a detection probability of 1.0, which is unrealistic and this method will likely produce negatively biased estimates of survival over the first 6 months of life. In general, radio-telemetry studies have indicated pup survival is similar to adult survival during months 7-12 after birth (Peterson et al. 1984, Fuller 1989, Adams et al. 2008). Consequently, we used 6 month survival rate of adults (~0.94), calculated as the square root of annual survival, to approximate survival of pups from ages 7-12 months. We used the product of summer survival rates times the 6 month survival rate of adult wolves as the annual estimate of pup survival (S_p) in our baseline model (0.73 × 0.94 = 0.68; Table 1).

Table 3. Survival rates of wolf pups from birth to six months reported in literature. Unless otherwise noted, survival was estimated by comparing pup counts six months after birth to in utero litter sizes. Annual survival rates calculated as the product of 6 month survival rates of pups and 6 month survival rates of adult wolves used in our model (0.88).

<table>
<thead>
<tr>
<th>Source</th>
<th>Survival from birth to 6 months</th>
<th>Annual survival^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuller (1989)^b</td>
<td>0.58</td>
<td>0.55</td>
</tr>
<tr>
<td>Mills et al. (2008)^c</td>
<td>0.83</td>
<td>0.78</td>
</tr>
<tr>
<td>Fritts and Mech</td>
<td>0.57</td>
<td>0.53</td>
</tr>
<tr>
<td>Fuller and Keith (1980)</td>
<td>0.69</td>
<td>0.65</td>
</tr>
<tr>
<td>Adams et al. (2008)</td>
<td>0.81</td>
<td>0.76</td>
</tr>
<tr>
<td>Hayes and Harestead (2000)^d</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>Petersen et al. (1984)</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>Ballard et al. (1987)</td>
<td>0.82</td>
<td>0.77</td>
</tr>
<tr>
<td>Mech et al. (1998)^e</td>
<td>0.91</td>
<td>0.85</td>
</tr>
<tr>
<td>Hayes et al. (1991)^f</td>
<td>0.48</td>
<td>0.45</td>
</tr>
<tr>
<td>Mean survival</td>
<td>0.73</td>
<td>0.68</td>
</tr>
</tbody>
</table>

^a Annual survival is the product of survival from birth to 6 months and the 6 month survival rate of adult wolves used in our model.
^b Survival rate reported was estimated over 8 month period using pup counts. Monthly survival rate was 0.9135 and survival over six months was 0.58.
^c Survival was estimated with implant transmitters from Jun-Nov. Used monthly survival rates from this period to estimate 6 month survival rate.
^d Survival estimated on an annual interval. Used the square root of reported survival rates to estimate survival from birth to 6 months.
^e Survival estimate over first 4 months of life. Extrapolated to 6 months.
^f Heavily exploited wolf population.
We compared the pup survival rates used in our model to pup count data collected in Oregon during winter surveys conducted from 2009-2014. During this time frame, 30 potential reproductive opportunities were documented. Of these 30 potential reproductive opportunities, 3 were censored because final pup counts were not completed. Assuming wolves give birth to an average of 5 pups per litter (Fuller et al. 2003), we calculated a total of 135 pups born from these 27 reproductive opportunities. Minimum pup counts conducted in December of 2009-2014 indicated a minimum of 82 pups across all years. Using this information we arrived at a minimum observed survival rate of 0.61 (95% CI = 0.53 – 0.69), which is lower but within in the range of the pup survival rate used in our model (0.68 ± 0.15; Table 1).

When implementing our model, annual survival rates were independently calculated for each age class by randomly drawing a survival rate from a uniform distribution with a predefined mean and standard deviation (Table 1). Survival rates of wolves were age-specific and were not influenced by social status of the individual (e.g., survival rates for a 4-year old sub-dominant adult were identical to survival rates for a 4-year old dominant adult). Survival rates were modeled at an individual level, with each individual having an independent probability of survival at each time step.

Density-dependence.— When populations surpassed a predefined population threshold, annual survival rates, regardless of age, were multiplied by the ratio of the threshold population size and current wolf population size. The specified threshold was implemented to account for the importance of density-dependence on population dynamics (Morris and Doak 2002), but does not represent an expected number of wolves in Oregon in future years. When implemented in our model, the density-threshold represents an arbitrary biological threshold where wolves begin to self-regulate through intraspecific strife or are limited by available prey.

Larsen and Ripple (2006) created a habitat suitability map for wolves in Oregon and found that a maximum of 1,450 wolves could occupy Oregon. This value increased to 2,200 wolves if industrial timberland in western Oregon was classified as suitable wolf habitat. Fuller et al. (2003) provided the following equation to estimate expected wolf densities:

\[
\text{Wolves/1,000 km}^2 = 3.5 + 3.27 \times U
\]

, where \( U \) is the ungulate biomass index (km\(^2\)). Using an estimated elk (\textit{Cervus elaphus}) population of 128,000 elk distributed across 151,500 km\(^2\) of summer range habitat (ODFW, unpublished data) and assigning each elk a biomass value of 3, results in a value of \( U \) of 2.53 (128,000 \times 3/151,500). Based on this value maximum wolf densities were estimated to be 11.79 wolves/1,000 km\(^2\) of summer range elk habitat. This would result in a total population of 1,780 wolves within 151,500 km\(^2\) of elk summer range habitat in Oregon. Carbone and Gittleman (2002) provided the following equation to estimate wolf densities based on available primary prey biomass:

\[
\text{Number of wolves} = 0.62 \times \text{primary prey biomass}
\]

, where primary prey biomass is scaled per 10,000 kg. Currently, Oregon’s elk population is approximately 128,000 with each elk weighing on average 217 kg (ODFW, unpublished data). This results in approximately 2,777.6 \times 10,000 kg of primary prey biomass available to wolves across Oregon and a maximum population estimate of approximately 1,722 wolves.

Both the Fuller et al. (2003) and Carbone and Gittleman (2002) equations produce similar estimates of wolf population size and fall within the range reported by Larsen and Ripple (2006). However, these estimates were calculated under the assumption wolves will not cause reductions in prey populations. To account for this possibility, we used a conservative density-threshold (CC) of 1,500 wolves in our model. Again, it should be noted, the density-threshold represents
an estimate of maximum potential wolf population size, not a management objective for wolves in Oregon.

Prey multiplier.—Wolf-prey interactions can influence wolf densities and population dynamics (Fuller et al. 2003). We lacked sufficient data to explicitly model wolf-prey interactions and instead used a simplified approach described by Bull et al. (2009) where a stochastically generated a prey multiplier value (Pr) was used to represent changes in either prey abundance or vulnerability (e.g., increased vulnerability during severe winters). The prey multiplier represented environmental stochasticity in our model. At a value of 1.0, the prey multiplier represented baseline prey availability or vulnerability. Each year of the simulation, the prey multiplier had a 1 out of 3 chance of increasing, decreasing, or remaining the same, respectively. In years the prey multiplier increased or decreased, the maximum change was restricted to 0.10. The prey multiplier was bounded between 0.90 and 1.10 values generated outside this range were truncated to the maximum or minimum value. Survival rates used in the model were calculated as the product of randomly drawn survival rates and the prey multiplier after accounting for any density-dependent effects.

Dispersal and Emigration.—We assumed dominant wolves would maintain their territory and breeding positions until their death. In the event that both dominant animals in a pack died, all remaining pack members would disperse. This approach was partially used for simplicity of model implementation, but is also supported in literature (Fuller et al. 2003). For example, Brainerd et al. (2008) found that in instances where both breeding wolves were lost, 85% of packs dissolved, and only 9% of packs reproduced the following year.

Sub-dominant wolves that survived the year had a probability of dispersing from their existing territory, which was dependent on age and breeding status (Table 1). Age-specific dispersal rates used in our model (Dp, Dy, Dad) were obtained from literature (Potvin 1988, Fuller 1989, Gese and Mech 1991). We assumed non-breeding adults had similar dispersal rates as yearlings (Fuller et al. 2003). Survival rates of dispersing individuals were reduced (Md) to account for increased mortality risk of wolves during dispersal (Table 1; Peterson et al. 1984, Fuller 1989, Smith et al. 2010). Smith et al. (2010) found dispersing wolves had a 38.9% higher risk of mortality over 365 days than resident wolves. After accounting for this increased risk, survival rates of dispersing adult wolves would be 0.83 with the ratio of dispersing versus resident adult survival rates of 0.94 (0.83/0.88). To be conservative, we lowered this value to 0.90 (± 0.05 SD) for use in our model, which is interpreted at 10% of dispersing wolves die during the dispersal process.

We used a spatial simulation to estimate emigration rates using published estimates of dispersal distances of wolves (Fritts and Mech 1981, Fuller 1989, Gese and Mech 1991, Wydeven et al. 1995). We generated 10,000 random dispersal paths that started at a random location within summer range elk habitat (i.e., potential wolf habitat). We simulated dispersal paths using correlated random walks with the movement.simplecrw function in the Geospatial Modeling Environment (Beyer 2012) by selecting a random bearing from a uniform distribution (0 - 359°) and a random dispersal distance from normal distribution with a mean of 75 km (± 30 SD). We calculated emigration rates (Ed) as the proportion of simulated dispersal paths that terminated outside Oregon. Mean emigration rates were estimated to be 0.115 (Table 1). We estimated a standard deviation of the mean values calculated from 100 bootstrap samples that each contained 100 random dispersal paths. The estimated standard deviation of the mean of these 100 samples was 0.03. Emigration was effectively treated as additional mortality in our model (i.e., these individuals were removed from the simulated population).
**Territory Establishment.**—Dispersing wolves $\geq 2$ years old were assigned a probability of establishing a territory. Boyd and Pletscher (1999) found that 57% of dispersing wolves successfully found a mate the next breeding season after they dispersed. This value equates to the joint probability of two wolves establishing a territory. Independently, the probability of a dispersing wolf establishing a territory ($T$) would be 0.75 ($\sqrt{0.57}$), which we used in our model. Wolves that did not successfully establish a territory remained in the pool of dispersers until the following year. Those individuals that successfully established territories would first fill vacant alpha positions of the correct sex in established packs. If no alpha positions were available at established packs, dispersing wolves would then establish a new territory and maintain that position until they died or a mate joined them at the territory.

**Immigration.**—We assumed wolves from the extant Rocky Mountain wolf population would be available to immigrate into Oregon. For model simplification, we assumed the wolf population outside Oregon was unstructured and would produce a steady, but limited, stream of immigrants. We assumed 3 wolves ($\pm 2$ SD) would arrive immigrate (I) annually into Oregon from surrounding populations. We assumed all immigrating wolves were sub-adults because this age class is most likely to engage in dispersal behavior (Fuller 1989, Gese and Mech 1991, Fuller et al. 2003). Individuals arriving in the Oregon population were randomly assigned a sex assuming parity among dispersers (Gese and Mech 1991).

**Anthropogenic Mortality.**—Anthropogenic mortality was incorporated in the model under two forms: legal and unauthorized mortality. Unauthorized mortality represented all sources of anthropogenic mortality (e.g., poaching, vehicle-killed individuals) excluding mortalities authorized by ODFW under current laws. Legal removals included any administrative removals authorized by ODFW (e.g., livestock damage, human safety, incidental take). Anthropogenic mortality was modeled using a two-step process where unauthorized mortality was modeled first and followed by legal mortality. A proportion of the total population that remained after accounting for natural mortality events would be removed each year by each anthropogenic mortality source (Table 1). Anthropogenic mortality was applied independent of age, social status, or pack membership. Effectively, this approach treats anthropogenic mortality as a reduction in survival. For example, using an annual adult survival rate of 0.88, survival rates would be reduced to 0.79 (0.88 $\times$ 0.95 $\times$ 0.95) if 5% of the population was removed for both legal and unauthorized mortality, respectively.

From April 2009 to March 2015, ODFW has collected 54 wolf-years of data from radio-collared individuals. During this time, 1 radio-collared wolf was illegally killed and 1 radio-collared wolf was removed by ODFW, for a removal rate of 0.02 for each mortality source (ODFW, unpublished data). Due to the potential bias of radio-collared wolves being avoided by poachers, we increased the illegal mortality (IM) value to 0.05 ($\pm$ 0.03 SD). To be conservative and allow for the potential of increased levels of lethal control actions, we used a value of 0.05 ($\pm$ 0.03 SD) for legal mortality (LM) of wolves in our model (i.e., between 2-8% of wolves would be randomly removed from the population each year for management related actions).

**Reproduction.**—Only established wolf packs with a dominant pair of adults were allowed to reproduce. We were unable to find reported estimates of pregnancy rates of dominant females in published literature; however, it is biologically unrealistic to assume all pairs of wolves successfully give birth to pups each year (i.e., female do not always become pregnant). We assumed pregnancy rates of dominant females ($P_{ad}$) would be 0.95 ($\pm$ 0.02 SD; Table 1). While evidence exists of multiple females producing pups within a pack, this is a rare occurrence and usually only occurs in extremely large packs (Mech 1999), and we assumed only one litter of
pups would be born in packs with a dominant pair. The number of pups produced by pregnant females (L) was drawn from a uniform distribution ranging from 2-8 (Table 1) based on a review of literature (see summary in Fuller et al. 2003).

*Catastrophes.*—We included two catastrophes in our model. The first was modeled at the pack level as the probability of a pack having complete reproductive failure within a year (R<sub>cat</sub>). Probability of reproductive failure was independent among packs and years. This approach was used to simulate the potential effects of diseases (e.g., canine parvovirus), which are known to negatively affect pup survival and recruitment (Mech and Goyal 1993, Almberg et al. 2009), where most or all pups die when exposed to the virus (Mech et al. 2008). We assumed complete reproductive failure had a probability of occurrence of 0.05 within each pack during each year of the simulation (i.e., one out of 20 litters will be subjected to complete reproductive failure). Packs that had complete reproductive failure were assigned a litter size of 0 (i.e., even if pups were produced they would all die before 1 year of age).

Our second catastrophe was modeled at the population level, where each year of the simulation there was a probability of a population wide reduction in survival (S<sub>cat</sub>). This approach was used to represent extremely rare, range wide events that may affect wolf populations (e.g., disease, abiotic conditions, prey population crashes). We used a mean interval of 100 years between disturbance events, with each year having an independent probability of a disturbance event occurring. During years where a catastrophe event occurred, survival rates of all wolves in the population were reduced by 25%.

**Assessment of Population Viability**

We assessed population viability using two measures. The Oregon Wolf Plan defined a threshold of 4 breeding pairs for 3 consecutive years as a guideline to consider delisting wolves from the Oregon ESA (ODFW 2010). Consequently, we defined “conservation-failure” as a simulated population that fell below 4 breeding pairs. For each simulated population, we determined which time-step, if any, that the population dropped below the conservation-failure threshold. Simulated populations that dropped below the conservation-failure threshold were considered failures in all remaining time steps. We calculated risk of conservation-failure as the cumulative proportion of simulated populations that had < 4 breeding pairs.

We used a threshold of < 5 wolves as our metric of “biological-extinction”. In simulations with < 5 wolves, the extant population would effectively be extirpated and immigrants from outside sources would be maintaining the Oregon population. For each simulated population, we determined the time-step, if any, that the population dropped below the biological-extinction threshold. Once the population dropped below this threshold it was determined to be biologically-extinct for all remaining time steps. We calculated biological-extinction rates as the cumulative proportion of simulated populations that < 5 wolves.

**Model Validation**

To validate our baseline model, we conducted a set of 100 realizations of population growth over 5 years, where the starting population size was the number of wolves present in Oregon at the end of 2009 (N = 14 wolves). We calculated the mean number of wolves and breeding pairs from simulations and compared these values to population counts conducted by ODFW from 2010-2014. Survival rates used in our baseline model were more conservative than observed in Oregon from 2010-2014. Consequently, we conducted a second set of simulations where we parameterized our model with vital rates required to match observed population growth rates in Oregon from 2009-2014 (see Table 1 for differences between vital rates in the two scenarios). Using observed vital rate values in our model would allow us to determine if our
overall model structure allowed accurate estimation of population growth under known conditions.

**Sensitivity Analysis**

*Effects of Stochastic Parameters.*– We used \( r \) (i.e., intrinsic rate of increase) as the dependent variable in a linear regression model where stochastically varying parameters and relevant interactions were used as independent variables. We conducted 200 realizations of population growth over a 5-yr period which resulted in 1,000 random combinations of parameter values and associated intrinsic growth rates \( (r) \). The sensitivity analysis was limited to a 5-yr span because allowing population simulations to last longer than 5-yrs could cause some simulations to reach the density-threshold of 1,500 wolves and confound the effect of parameter variation and density-dependence on \( r \). For each simulation, the starting population was assumed to be 120 wolves equally distributed among 20 packs. We used this starting population size because at extremely small population sizes (e.g., \( N < 10 \)) immigration of wolves could produce biologically unreasonable population growth rates (e.g., \( \lambda > 2.0 \)) and confound our ability to detect an effect of parameters on \( r \). Prior to running our regression model, all independent variables were standardized (standardized value = \([\text{observed value} - \text{mean value}] / \text{standard deviation}\)) to allow direct comparisons between results. We used an alpha level of 0.05 to determine significance of parameters and the sign and slope of beta coefficients to determine the strength and relative effect of the parameter on \( r \).

*Effects of Static Parameters.*– Starting population size, density-threshold, and frequency of survival and reproductive catastrophes were static parameters in our model and the effects of these were not included in our regression analysis used to determine the relative effects of parameters on \( r \). Consequently, we conducted additional simulations where values of static parameters differed among simulations. Each simulation used 100 realizations of population growth over 50 years and was parameterized with baseline values except for changes in the static parameter of interest. We conducted 4 simulations to determine the effect of starting population sizes of 50 wolves, the known existing Oregon wolf population (\( N = 85 \); baseline value), 100 wolves and, 150 wolves. Simulations with starting populations of 50, 100, and 150 wolves were structured as follows: 1) each wolf belonged to a pack and each pack had 5 members with 2 of those members being dominant adults and 2) sex, age, and social class of remaining wolves were randomly assigned. To determine the relative influence of the density-threshold on population viability of wolves, we conducted a set of simulations where used a density-threshold of 100, 250, 500, 1000, and 1500 (baseline value) wolves. We conducted a set of 3 simulations where we investigated probabilities of individual pack reproductive failure of 0.05 (baseline value; once every 20 litters), 0.10 (once every 10 litters), and 0.20 (once every 5 litters). We investigated the effects catastrophic reductions in survival at year-specific probabilities of 0.01 (baseline value; once every 100 years), 0.02 (once every 50 years), 0.05 (once every 20 years), and 0.10 (once every 10 years).

*Effects of lethal control of wolves*

Legal, anthropogenic mortality is the parameter included in our model over which ODFW has the most control. To address the effects of varying rates of legal wolf removal on wolf population viability we conducted a set of 4 simulations where mean legal mortality rates and associated standard deviations varied among simulations while all other model parameters were left at baseline values (Table 1). The following values were used as mean values (± SD) to represent legal anthropogenic mortality rates in the 4 simulations: 0.00 (± 0.00), 0.05 (± 0.03),
These levels of legal mortality rates were in addition to illegal mortality rates which were set at a mean value of 0.05 (± 0.03) during all simulations.

Our baseline model assumes legal removals will be implemented through random removal of individual wolves. However, the potential exists that lethal control actions could take place across entire wolf packs, rather than individuals. Consequently, we also conducted a simulation where legal removal of wolves would occur at a pack rather than individual level. We assumed the proportion of packs removed per year would be the same as the proportion of individuals removed in our baseline simulation (0.05 ± 0.03). After completion of simulations, we compared the results to the baseline simulation to determine what effect, if any, pack removal would have on population dynamics compared to individual removal.

**RESULTS**

**Model Validation**

Our baseline model resulted in underestimates of population size (Fig. 3a) and number of breeding pairs (Fig. 3b) compared to population count data collected in Oregon from 2010-2014. When our model was parameterized with survival rates of wolves observed from 2009-2014 (Table 1) the simulation results closely approximated observed population size and number of breeding pairs. Consequently, survival rates used in our baseline model are cautious compared to past survival rates in Oregon; however, the ability of the model to correctly predict past population dynamics when parameterized with observed survival rates suggests other parameters included in the model accurately portray wolf population dynamics in Oregon. Our baseline model predicted lower population growth compared to the model parameterized with survival rates observed from 2009-2014. This suggests our baseline model will underestimate wolf population growth and viability if survival rates from 2009-2014 are observed into the future.

**Assessment of Population Viability**

Using our baseline model, simulated wolf populations increased an average of 7% (i.e., λ = 1.07 ± 0.17 SD) per year. Over the next 50 years, there was a 0.05 (95% CI = 0.01 – 0.09) probability of the population dropping below the conservation-failure threshold (Fig. 4). Most conservation-failures (3 out of 5) occurred within the first 10 years and by year 20, no additional populations passed the threshold. Of the five simulated populations that fell below the conservation-failure threshold, all eventually surpassed 4 breeding pairs in the future with these populations having 7, 20, 39, 84 and 194 breeding pairs in year 50 of the simulation, respectively. There was a 0.01 (95% CI = 0.00 – 0.03) probability the simulated population dropped below the biological-extinction threshold over the next 50 years. The single simulated population that dropped below 5 individuals recovered to 360 individuals by year 50.

Using observed survival rates of wolves from 2009-2014 in our population model resulted in no scenarios where wolf populations dropped below the conservation-failure or biological-extinction thresholds. Our baseline model may be more likely to represent future population dynamics of wolves, but may be overly pessimistic, especially in the near future, given recently observed survival rates of wolves in Oregon. Consequently, we contend future risk of conservation-failure likely falls somewhere between our baseline model (0.05) and our model parameterized with vital rates required to match observed population growth rates from 2009-2014 (0.00). Our model results suggest it is extremely unlikely (≤ 0.01 probability) wolves in Oregon will be at risk of extirpation over the next 50 years.
Figure 3. Comparison of (a) simulated mean population sizes compared to minimum population sizes observed in Oregon from 2009-2014 and (b) simulated number of breeding pairs to minimum number of known breeding pairs in Oregon from 2009-2014 using baseline simulation parameters (dashed line) or observed model parameters (solid line). Black dots represent observed wolf population size and number of breeding pairs determined from annual surveys of wolf populations conducted by ODFW. Polygons around simulated mean population sizes and number of breeding pairs represent 95% confidence intervals.
Sensitivity Analysis

Effects of Stochastic Parameters.—Nine out of 17 stochastic parameters included in our baseline model had a significant effect on intrinsic growth rates as measured by \( r \), and no significant interactions between parameters were documented (Table 4). Most significant effects (Fig. 5) were directly or indirectly related to survival rates. Survival rates of pups (\( S_p; \beta = 0.045 \)), yearlings (\( S_y; \beta = 0.024 \)), and adults (\( S_{ad}; \beta = 0.019 \)) were positively associated with \( r \). The prey multiplier (\( Pr \)) increased variation in survival rates of all age classes of wolves by up to 20% and resulted in the prey multiplier, which represented increased environmental stochasticity, having the greatest effect on \( r \) (\( \beta = 0.088 \)). Illegal (IM; \( \beta = -0.027 \)) and legal (LM; \( \beta = -0.028 \)) anthropogenic mortality were negatively associate with \( r \).
Table 4. Results of linear regression model used to estimate sensitivity of intrinsic growth rates of wolf populations in Oregon using an individual-based population model. Standardized regression coefficients with associated standard errors estimated from the full model are provided. Significance is determined as follows: *** = P < 0.001, ** = P < 0.01, * = P < 0.05, and NS = P > 0.05.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standardized $\beta_i$</th>
<th>SE</th>
<th>P-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pup survival</td>
<td>0.045</td>
<td>0.007</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Yearling survival</td>
<td>0.024</td>
<td>0.007</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Adult (2 to 7-yrs old) survival</td>
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<td>0.007</td>
<td>0.006</td>
<td>**</td>
</tr>
<tr>
<td>8-yr old adult survival</td>
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<td>0.007</td>
<td>0.411</td>
<td>NS</td>
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<tr>
<td>9-yr old adult survival</td>
<td>-0.002</td>
<td>0.007</td>
<td>0.789</td>
<td>NS</td>
</tr>
<tr>
<td>Pup dispersal</td>
<td>0.007</td>
<td>0.007</td>
<td>0.295</td>
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<tr>
<td>Yearling dispersal</td>
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<td>0.007</td>
<td>0.155</td>
<td>NS</td>
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<td>Adult dispersal</td>
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<td>0.007</td>
<td>0.833</td>
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<tr>
<td>Proportion of dispersing wolves that die</td>
<td>-0.026</td>
<td>0.007</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>No. of immigrants arriving annually</td>
<td>0.009</td>
<td>0.005</td>
<td>0.109</td>
<td>NS</td>
</tr>
<tr>
<td>Proportion of dispersing wolves that emigrate</td>
<td>-0.005</td>
<td>0.007</td>
<td>0.443</td>
<td>NS</td>
</tr>
<tr>
<td>Proportion of dispersing wolves that successfully establish a territory</td>
<td>0.034</td>
<td>0.006</td>
<td>0.000</td>
<td>***</td>
</tr>
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<td>Pregnancy rate for dominant females</td>
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<td>0.007</td>
<td>0.912</td>
<td>NS</td>
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<tr>
<td>Mean litter size</td>
<td>0.049</td>
<td>0.004</td>
<td>0.000</td>
<td>***</td>
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<tr>
<td>Prey index multiplier</td>
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<td>0.005</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Illegal mortality</td>
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<td>0.007</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Legal mortality</td>
<td>-0.028</td>
<td>0.007</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Pup survival × Prey multiplier index</td>
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<td>0.009</td>
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<td>Yearling survival × Prey multiplier index</td>
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<td>Yearling survival × Legal mortality</td>
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<td>0.912</td>
<td>NS</td>
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<td>Adult survival × Legal mortality</td>
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<td>0.012</td>
<td>0.342</td>
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<td>Pup survival × Dispersal mortality</td>
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<td>0.011</td>
<td>0.248</td>
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<td>Yearling survival × Dispersal mortality</td>
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<td>0.012</td>
<td>0.824</td>
<td>NS</td>
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<tr>
<td>Adult survival × Dispersal mortality</td>
<td>0.003</td>
<td>0.011</td>
<td>0.785</td>
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Figure 5. Estimated effects of significant ($p < 0.05$) model parameters on intrinsic growth rates of wolf populations. Estimates were generated using baseline model parameterization. Results generated from 1,000 unique combinations of model parameters and associated intrinsic growth rates. Model parameters are standardized to allow direct comparison among parameters. Black line represents estimated regression line. Gray dots represent individual parameter estimates and associated population growth rate.
Increased mortality rates of dispersing wolves ($M_d; \beta = -0.026$) had a negative effect on $r$. This parameter negatively affected $r$ in two ways: 1) wolves were directly removed from the population and 2) fewer wolves were available to establish territories and contribute to population level reproduction. Increased probabilities of dispersing wolves successfully establishing a territory had a positive effect on $r$ ($T; \beta = 0.034$). Mean litter size ($L; \beta = 0.049$) was positively correlated with $r$. Pregnancy rates of dominant females ($P_{ad}$) were not significantly associated with $r$. We likely did not find a significant effect of pregnancy rates because of the high mean value (0.95) and low variation (SD = 0.02) used in our model.

Dispersal rates, regardless of age class ($D_p$, $D_y$, and $D_{ad}$) had minimal effects of on $r$ (Table 4). Both immigration ($I$) and emigration ($E_d$) did not have a significant effect on $r$. At most, our model limited the number of immigrating wolves to 5 per year (range = 1 – 5) and contributions to population growth from immigrants will be limited except for extremely small extant populations. We modeled emigration rates as a proportion of the dispersing wolves that survived and left the population each year. Consequently, emigration could contribute to reduced population growth rates when the number of emigrants is greater than the number of immigrants. This scenario is more likely to occur for large extant populations.

**Effects of Static Parameters.** As expected, simulations with larger starting populations reached the density-threshold faster than those with smaller starting size (Fig. 6a). The risk of conservation-failure declined with increased starting population size (Fig. 6b). Using our baseline model, simulations that started with 150 and 100 individuals had no risk and a 0.01 (95% CI = 0.00 – 0.03) probability of conservation-failure over the next 50 years, respectively. At the current minimum known wolf population in Oregon, risk of conservation-failure (0.05; 95% CI = 0.01 – 0.09) was slightly higher than if 100 animals were in the population but substantially lower than if only 50 wolves (0.14; 95% CI = 0.07 – 0.21) occurred in Oregon. We did not observe a relationship between starting population size and biological-extinction risk as biological-extinction risk was ≤ 0.01 over 50 years regardless of starting population size.

Unsurprisingly, mean maximum population sizes of wolves were larger for simulations with higher density-thresholds (Fig. 7a). The effects of varying density-thresholds on risk of conservation-failure over 50 years were similar for density thresholds between 250 – 1500 (range 0.03 – 0.05; Fig. 7b). In contrast, at a density-threshold of 100 wolves, risk of conservation-failure was much greater (0.64; 95% CI = 0.55 – 0.73), steadily increased over time, and never plateaued as observed in other simulations. This suggests that a population threshold of 100 wolves is insufficient to allow long-term persistence of ≥ 4 breeding pairs. Regardless of the density-threshold used, maximum observed biological-extinction risk was ≤ 0.01.

Increased frequency at which catastrophic reductions in survival rates occurred caused reduced population growth rates and reduced mean, maximum population size of wolves (Fig. 8a). Populations that were subjected to catastrophic reductions in survival at intervals of once every 100 or 50 years had a relatively low risk of conservation-failure (range = 0.05 – 0.06; Fig. 8b). Catastrophic reductions in survival at intervals of once every 20 (0.09; 95% CI = 0.03-0.15) and 10 (0.16; 95% CI = 0.09-0.23) years had moderate risk of conservation-failure compared to less or more frequent intervals. For all scenarios, biological extinction risk was ≤ 0.01 over 50 years.
Figure 6. Estimated effect of variation in starting population size on (a) mean population size and (b) cumulative probability of conservation-failure (< 4 breeding pairs) over the next 50 years in Oregon. Current population size (N = 85) was the minimum wolf population size in Oregon as of April 1, 2015. Cumulative probability of conservation-failure represents the cumulative proportion of simulated populations that reached the conservation-failure threshold. All estimates generated using 100 realizations of population growth over 50 years using the baseline model parameterization.
Figure 7. Estimated effect of variation in density-threshold on (a) mean population size and (b) cumulative probability of conservation-failure (< 4 breeding pairs) over the next 50 years in Oregon. Cumulative probability of conservation-failure represents the cumulative proportion of simulated populations that reached the conservation-failure threshold. All estimates generated using 100 realizations of population growth over 50 years using baseline model parameterization.
Figure 8. Estimated effect of variation in interval between catastrophic reductions in survival of wolves on (a) mean population size and (b) cumulative probability of conservation-failure (< 4 breeding pairs). Cumulative probability of conservation-failure or biological extinction represents the cumulative proportion of simulated populations that reached the specified threshold. All estimates generated using 100 realizations of population growth over 50 years using baseline model parameterization.
Increased frequency of pack-specific reproductive failure reduced population growth rates and mean, maximum population size of wolves (Fig. 9a). Scenarios with reproductive failure once every 20 (0.05; 95% CI = 0.01 – 0.09) and 10 litters (0.05; 95% CI = 0.01 – 0.09) had similar risk of conservation-failure in the next 50 years (Fig. 9b). Risk of conservation-failure was almost 6 times greater at intervals of once every 5 litters (0.29; 95% CI = 0.20 – 0.38). These results highlight the importance of pup production on ensure population viability of wolves. Risk of biological-extinction was not strongly affected by interval of reproductive failure as all scenarios had a risk of biological-extinction ≤ 0.02.

Figure 9. Estimated effect of variation in intervals between reproductive failure on (a) mean population size and (b) cumulative probability of conservation-failure (< 4 breeding pairs) over the next 50 years in Oregon. Cumulative probability of conservation-failure represents the cumulative proportion of simulated populations that reached the conservation-failure threshold. All estimates generated using 100 realizations of population growth over 50 years using baseline model parameterization.
Effects of lethal control of wolves

Increased rates of legal mortality, while holding illegal mortality at baseline values, had a negative effect on population growth rates and mean, maximum population size of wolves (Fig. 10a). With a starting population of 85 wolves and at a legal mortality rate of 0.20, wolf populations declined. This suggested this rate of legal mortality was not sustainable over the long-term at least at a starting population of 85 wolves and additional illegal mortality of 0.05. At a mean legal mortality rate of 0.05, which was used in our baseline model, probability of conservation-failure was 0.05 (95% CI = 0.01 – 0.09; Fig. 10b) over the next 50 years. At a reduced mean legal mortality rate of 0.00, no simulated populations dropped below the conservation-failure threshold. Probability of conservation-failure increased to 0.40 (95% CI = 0.30 – 0.50) and 1.00, for mean legal mortality rates of 0.10 and 0.20, respectively, when combined with illegal mortality rates of 0.05. Combined, these results highlight the importance of minimizing anthropogenic mortality to benefit population viability of wolves. Probability of biological-extinction was relatively low for all simulations with mean legal mortality rates ≤ 0.10 (range = 0.00 – 0.07; Fig. 10c). In contrast, mean legal mortality rates of 0.20 resulted in an extremely high probability of biological extinction (0.90; 95% CI = 0.84 – 0.96), at least when combined with an illegal mortality rate of 0.05 and a starting population of 85 individuals. Larger populations will be able to sustain higher mortality rates because they will have a greater buffer between extant population size and thresholds of biological extinction.

It should also be noted, the levels of anthropogenic mortality used in our model are not directly comparable to mortality rates commonly reported in literature (i.e., 1 – survival rate). Anthropogenic mortality rates as implemented in our model represent the proportion of wolves that would be removed from the population after accounting for natural mortality. For example, using a legal mortality rate of 0.10, an illegal mortality rate of 0.05, and a survival rate in the absence of anthropogenic mortality of 0.88, would result in an observed survival rate of 0.75 (0.88 × 1-0.10 ×1-0.05).

The effects of legal removals on wolves reported above are predicated on a starting population of 85 wolves. At larger population sizes, wolves will have an increased buffer between extant population size and conservation-failure or biological-extinction thresholds and fewer simulations would be expected to cross these thresholds. This is particularly true for moderate levels of legal mortality (0.05-0.15) where populations are likely to increase on average, but without a sufficient buffer and under stochastically varying conditions, 2-3 consecutive years of negative population growth could push the population below a predefined threshold. This phenomenon is evident in our simulations because most conservation-failures occurred shortly after simulations started. By later years, population sizes had sufficiently increased that they were able to withstand several consecutive years of negative population growth without falling below the conservation-failure threshold.

Comparison of individual vs. pack removal. –Lethal control actions conducted through random removal of individuals or entire packs had little influence on mean population size over 50 years (Fig. 11a). Mean populations for both removal scenarios reached the density-threshold (N = 1,500) by the 50th year of the simulation. Conservation-failure rates over 50 years were similar if individual wolves (0.05; 95% CI = 0.01 – 0.09) or packs (0.08; 95% CI = 0.03 – 0.13) were removed (Fig. 11b). Entire pack removal (0.01; 95% CI = 0.00 – 0.03) and removal of individuals (0.01; 95% CI = 0.00 – 0.03) resulted in similar estimates of biological-extinction risk over 50 years.
Figure 10. Estimated effect of variation in legal removal rates (proportion of wolves that would have survived the year otherwise) of wolves on (a) mean population size, (b) cumulative probability of conservation-failure (<4 breeding pairs), and (c) cumulative probability of biological-extinction (<5 wolves) over the next 50 years in Oregon when the starting population size was 85 wolves. Cumulative probability of conservation-failure or biological extinction represents the cumulative proportion of simulated populations that reached the specified threshold. All estimates generated using 100 realizations of population growth over 50 years using baseline model parameterization. For all simulations, unauthorized morality rates of 0.05 (±0.03 SD) occurred in addition to varying levels of legal removal.
Figure 11. Estimated effect of individual versus pack level legal removal on (a) mean population size and (b) cumulative probability of conservation-failure (< 4 breeding pairs) over the next 50 years in Oregon. Cumulative probability of conservation-failure represents the cumulative proportion of simulated populations that reached the conservation-failure threshold. All estimates generated using 100 realizations of population growth over 50 years using baseline model parameterization. Pack level and individual removal rates were identical for each simulation (0.05 ± 0.03).
DISCUSSION

Our baseline model underestimated population growth rates of wolves compared to observed population counts conducted in Oregon from 2010-2014. This was a consequence of two factors: 1) our baseline model used lower survival rates than were observed from 2010-2014 and 2) at small population sizes demographic stochasticity can have a dramatic effect on population growth rates (Lande 1998, Fox and Kendall 2002). However, our model parameterized with survival rates of wolves radio-collared in Oregon from 2009-2014 allowed our model to track observed population growth rates during this timeframe. We contend these findings suggest our model structure is capable of accurately portraying population dynamics of wolves when survival rates used in the model are representative of current conditions. We used conservative survival estimates in our baseline model to ensure our PVA erred on the side of caution (i.e., precautionary principle; Myers 1993, Meffe et al. 2006). Consequently, our results represent a conservative view of population viability of wolves in Oregon.

If wolf populations in Oregon continue to follow vital rates observed from 2009-2014, our results indicated there would be no risk of conservation-failure or biological-extinction within the next 50 years. It is unlikely wolf populations in Oregon would continue to increase at observed population growth rates because established or exploited wolf populations do not increase as rapidly as protected or recovering populations (Ballard et al. 1987, Hayes and Harestad 2000, Fuller et al. 2003). Therefore, we contend results from our model parameterized with currently observed vital rates may present an overly optimistic view of wolf population dynamics moving forward in Oregon. Using our baseline model parameterized with vital rates obtained from a literature review, we documented a 0%, 3%, and 5% chance of conservation-failure over the next 5, 10, and 50 years, respectively (Fig. 4). Most risk of conservation-failure occurs in the short-term (e.g., 15 years) because Oregon’s extant wolf population is close to the conservation-failure threshold and a few years of poor population growth could cause the population to decline below the threshold. Furthermore, during the first few years of our simulations, population sizes are small, which allows demographic stochasticity to have a greater effect on population persistence (Vucetich et al. 1997).

Our baseline model suggested risk of conservation-failure was lower for populations that started with 100 or 150 wolves compared to the current population size observed in Oregon (N = 85; Fig. 6). This is not an unexpected finding because larger populations, regardless of species, have a reduced risk of extinction and can withstand longer periods of reduced population growth. These results highlight the importance of creating a buffer between extant population size and conservation-failure thresholds to allow for potential years of negative population growth. Furthermore, increased modeled starting population size will minimize effects of demographic stochasticity and increase population viability. Based on observed population growth rates from 2009-2014 (mean λ = 1.43) and known reproduction in 13 groups of wolves in 2015, Oregon’s wolf population is expected to surpass 100 wolves by the end of the biological year. At this population size, risk of conservation-failure will effectively be eliminated (≤ 0.01).

In general, factors that influenced wolf survival had the greatest effect on intrinsic growth rates of wolves (r) in our simulation models. In our model, pup, yearling, and adult survival all had significant effects on intrinsic growth rates of wolf populations (Fig. 5). However, variation in pup survival had a greater effect on intrinsic growth rates than yearling or adult survival. While population growth rates of most large mammals are usually most sensitive to changes in adult survival, variability in adult survival, in the absence of high levels of anthropogenic mortality, is usually minimal compared to juveniles (Promislow and Harvey 1990, Gaillard et al.
Catastrophic reductions in survival of 25% had little effect on population growth rates (Adams et al. 2008, Creel and Rotella 2010, Sparkman et al. 2011). As implemented in our model, anthropogenic mortality rates of 0.20 would cause survival rates of adult wolves to be 0.70 (i.e., a mortality rate of 0.30) and the wolf population would decline slightly. Therefore, it was expected that increased environmental stochasticity, modeled through our prey multiplier, had a negative effect on simulated wolf populations.

Anthropogenic mortality is the primary factor that influences dynamics of most wolf populations (Creel and Rotella 2010). Our model supported this conclusion because increased levels of anthropogenic mortality had a negative effect on intrinsic growth rates of wolves (Fig. 5). Furthermore, our simulation results indicated that increased rates of anthropogenic mortality resulted in increased risk of conservation-failure and biological-extinction when the initial population was 85 wolves (Fig. 10). Anthropogenic mortality is the parameter in our model over which ODFW has the most control and our results highlight that Oregon’s wolf population will continue to increase and become self-sustaining if anthropogenic mortality is limited.

Our baseline model used inputs of 0.05 for both illegal and legal anthropogenic mortality rates (i.e., 5% of wolves that do not die of natural causes will be removed by both illegal and legal mortality sources) and at this rate, risk of conservation-failure was low. If ODFW maintains mortality rates at or below this level, the wolf population is predicted to be at a low risk of conservation-failure (0.05) and biological-extinction (0.01). Sustained, high levels of anthropogenic mortality (e.g., 0.20) in a stochastically varying environment contributed to increased risk of conservation-failure in our simulations; however, this finding is predicated on our staring population size of 85 wolves. Larger populations would be able to sustain this level of anthropogenic mortality without reaching the conservation-failure threshold because there is an increased buffer between extant population size and the conservation-failure threshold. Our model suggested that total anthropogenic mortality rates (i.e., combined illegal and legal mortality) of 0.15 would result in an increasing population on average (\(\lambda = 1.03\)) but total anthropogenic mortality rates of 0.20 caused wolf populations to decline on average (\(\lambda = 0.98\)). Previous studies have indicated wolf populations can be sustained with mortality rates up to 0.25 - 0.30 (Adams et al. 2008, Creel and Rotella 2010, Sparkman et al. 2011). As implemented in our model, anthropogenic mortality rates of 0.20 would cause survival rates of adult wolves to be 0.70 (i.e., a mortality rate of 0.30) and the wolf population would decline slightly on average (\(\lambda = 0.98\)). Consequently, our model matches well with the results previous studies.

Catastrophic reductions in survival of 25% had little effect on population growth rates and viability of wolves if the interval between occurrences was \(\geq 50\) years (Fig. 8). Widespread, catastrophic events are impossible to predict and little can be done to directly mitigate their
effect. However, general tenants of population ecology provide insight into actions that can minimize their effects on population viability. The primary way to reduce effects of catastrophes on population viability is to maintain larger extant populations. Larger populations are more viable because they have a sufficient number of individuals to withstand population declines. In our model, catastrophic events occurred at the population level. This is likely a biologically unrealistic expectation because catastrophic events are likely to occur in geographic regions (e.g., Blue Mountains or Cascade Range) due to localized differences in environmental conditions. This geographic separation should reduce population level effects of catastrophic events because not all wolves would be subjected to the event in a single year. However, these smaller sub-populations would have a greater risk of localized extinction compared to the larger extant population. This highlights the importance of risk spreading through spatial distribution of wolves in ensuring the long-term viability of wolf populations.

Recruitment of pups into the adult population was a critical factor influencing population dynamics of wolves. While we did not directly include a recruitment parameter in our model, several factors that jointly influence pup recruitment had separate effects on wolf population growth and viability. Variation in mean litter size had a strong effect on intrinsic growth rates of wolves. Increased frequency of reproductive failure had a negative effect on population growth rates and viability. Finally, reductions in survival rates of pups had a negative effect on population growth rates of wolves. Pup production and recruitment affects wolf population growth and viability in two ways. At the end of the biological year, wolf pups typically represent a large fraction of the total wolf population (Fuller et al. 2003). Consequently, any reductions in pup recruitment will slow population growth rates of wolves in the short-term. In the long-term, reduced pup recruitment will affect the number of potential dispersing wolves in the population. Yearling wolves (i.e., recently recruited pups) are most likely to disperse and establish new territories (Gese and Mech 1991, Boyd and Pletscher 1999). Reduced pup recruitment will limit the number of potential dispersers in subsequent years, which should slow the rate of population growth because fewer dispersers will be available to establish territories and contribute to population level reproduction.

In our baseline model, we used a density-threshold value of 1,500 wolves. This value represented the biological phenomenon where population growth of wolves would be limited by availability of vulnerable prey (Fuller 1989, Mech et al. 1998, Fuller et al. 2003) or intraspecific mechanisms (Cariappa et al. 2011); however the ability of wolves to self-regulate through intrinsic mechanisms is thought to be limited (Keith 1983, McRoberts and Mech 2014). Varying the density-threshold value in our model had little effect on risk of conservation-failure at values $\geq 250$ wolves. Consequently, we contend our choice of a density-threshold value had minimal effects on our results.

The Oregon Wolf Plan (ODFW 2010) provides guidelines as to when lethal control of wolves can occur. Our results indicated increased levels of anthropogenic mortality negatively affect wolf population growth and viability. However, whether anthropogenic mortality was implemented at an individual or pack-level had little effect on our results. Caution should be used when implementing lethal control to address management concerns. For example, breeder loss can have a significant, negative effect on wolf population dynamics (Brainerd et al. 2008, Borg et al. 2015). Consequently, decisions regarding lethal removal of breeding wolves should be carefully considered.

Our analysis of wolf-population viability did not explicitly incorporate genetic effects. Genetic viability is a critical concern for any threatened or endangered population (Frankham et
al. 2002, Scribner et al. 2006) especially for extremely small, isolated populations (Frankham 1996). Inbreeding is a potentially serious threat to the long-term viability for small, isolated populations of wolves (Liberg 2005, Fredrickson et al. 2007) but can be minimized through connectivity to adjacent populations. As few as 1-2 immigrants per generation (~5 years) can be sufficient to minimize effects of inbreeding on wolf populations (Vila et al. 2003, Liberg 2005). High levels of genetic diversity in Oregon’s wolf population are likely to be maintained through connectivity to the larger northern Rocky Mountain wolf population. Wolves are capable of long-distance dispersal (Fritts 1983, Boyd and Pletscher 1999, Wabakken et al. 2007) which should allow a sufficient number of immigrants to arrive in Oregon so long as sufficient connectivity is maintained between populations in adjacent states (Hebblewhite et al. 2010). While our model did not account for genetic effects, we acknowledge the importance of genetics for isolated populations of mammals and recognize that genetic effects could become important if the Oregon wolf population becomes isolated from the remainder of the northern Rocky Mountain wolf population.

The IBM we used to assess wolf population viability in Oregon should provide a realistic biological representation of wolf population dynamics. However, our IBM does not have a spatial component and does not rely on habitat or other landscape features. Spatially-explicit models could provide a more biologically realistic representation of wolf population dynamics; however, spatially-explicit models require substantial amounts of data that is currently not available in Oregon to effectively parameterize the model. Habitat suitability maps have been developed for Oregon (e.g., Larsen and Ripple 2006), but these maps have not been validated and use of these maps would introduce another unknown source of error in population models. Furthermore, the effects of habitat on survival, reproduction, and dispersal of wolves in Oregon are unknown and it would be impossible to accurately model these effects without unwarranted speculation. For these reasons, we contend our non-spatial analysis of wolf population dynamics is currently the most appropriate approach to model wolf population dynamics and viability because it does not rely on unfounded assumptions that could lead to inappropriate conclusions.

We used our existing IBM to assess viability of wolves in the eastern Wolf Management Zone (WMZ) of Oregon (see ODFW 2010 for description of eastern WMZ). In this analysis, we restricted our starting population size to those wolves known to occur in the eastern WMZ as of April 1, 2015 (N = 76) and set the density threshold to 600 wolves compared to 1,500 wolves used in the statewide analysis. We selected the density-threshold for eastern WMZ using the equations following: Fuller et al. (2003) provided the following equation to estimate expected wolf densities:

\[
\text{Wolves/1,000 km}^2 = 3.5 + 3.27 \times U
\]

, where U is the ungulate biomass index (km\(^2\)). Using an estimated elk (*Cervus elaphus*) population of 66,000 elk distributed across 53,320 km\(^2\) of summer range habitat in the eastern WMZ (ODFW, unpublished data) and assigning each elk a biomass value of 3, results in a value of U of 3.71 (66,000 × 3/53,320). Based on this value maximum wolf densities were estimated to be 15.64 wolves/1,000 km\(^2\) of summer range elk habitat in the eastern WMZ. This would result in a total population of 834 wolves within 53,320 km\(^2\) of elk summer range habitat in the eastern WMZ.

Carbone and Gittleman (2002) provided the following equation to estimate wolf densities based on available primary prey biomass:

\[
\text{Number of wolves} = 0.62 \times \text{primary prey biomass}
\]

, where primary prey biomass is scaled per 10,000 kg. Currently, the elk population in the eastern WMZ is approximately 66,000 with each elk weighing on average 217 kg (ODFW, unpublished data). This results in approximately 1,432.2 × 10,000 kg of primary prey biomass available to wolves across the eastern WMZ and a maximum population estimate of approximately 888 wolves. To be conservative, we used a density-threshold of 600 wolves in the eastern WMZ.

Remaining methods and parameter inputs for this analysis were identical to those used in the statewide assessment of wolf population viability (Table 1). As with the statewide analysis, we used two metrics to assess population viability: 1) conservation-failure, defined as the population dropping below 4 breeding pairs and 2) biological-extinction, defined as the population having fewer than 5 individuals.

Using our baseline model, simulated wolf populations increased an average of 6% (i.e., \(\lambda = 1.06 \pm 0.17 \text{ SD}\) per year. Over the next 50 years, there was a 0.06 (95% CI = 0.01 – 0.11) probability of the population dropping below the conservation-failure threshold (Fig. S1). Half of the conservation-failures occurred within the first 10 years and by year 20 no additional populations passed the threshold. Of the six simulated populations that fell below the conservation-failure threshold, all eventually surpassed 4 breeding pairs in the future with these populations having 22, 37, 61, 67, 72, and 88 breeding pairs by year 50, respectively. No simulated populations dropped below the biological-extinction threshold over the next 50 years. Risk of conservation-failure in the eastern WMZ was slightly higher, but not significantly different, than risk at a statewide level (0.06 vs. 0.05; Fig. S2). Our simulation results suggested risk of conservation-failure declined with increasing starting population size (Fig. 6), so it was not surprising that the slightly smaller starting population in the eastern WMZ (N = 76) had a slightly higher risk of conservation-failure compared to the statewide population (N = 85).
Figure S1. Estimates of cumulative probability of simulated wolf populations reaching the conservation-failure (< 4 breeding pairs) or biological-extinction (< 5 wolves) thresholds over the next 50 years in the eastern Wolf Management Zone of Oregon. Estimates were generated using our baseline model parameterization with 100 realizations of population growth over 50 years. Cumulative probabilities represent the cumulative proportion of simulations that crossed the threshold of interest.

Figure S2. Estimates of cumulative probability of simulated wolf populations reaching the conservation-failure (< 4 breeding pairs) over the next 50 years across the entire state or in the eastern Wolf Management Zone of Oregon. Estimates were generated using our baseline model parameterization with 100 realizations of population growth over 50 years. Cumulative probabilities represent the cumulative proportion of simulations that crossed the threshold of interest.
LITERATURE CITED


Beyer, H. L. 2012. Version 0.7.2.0. Spatial Ecology LLC.


(1) After investigation of the supply and condition of wildlife, the State Fish and Wildlife Commission, at appropriate times each year, shall by rule:

(a) Prescribe the times, places and manner in which wildlife may be taken by angling, hunting, trapping or other method and the amounts of each of those wildlife species that may be taken and possessed.

(b) Prescribe such other restrictions or procedures regarding the angling, taking, hunting, trapping or possessing of wildlife as the commission determines will carry out the provisions of wildlife laws.

(2) In carrying out the provisions of subsection (1) of this section, the power of the commission includes, but is not limited to:

(a) Prescribing the amount of each wildlife species that may be taken and possessed in terms of sex, size and other physical characteristics.

(b) Prescribing such regular and special time periods and areas closed to the angling, taking, hunting and trapping of any wildlife species when the commission determines such action is necessary to protect the supply of such wildlife.

(c) Prescribing regular and special time periods and areas open to the angling, taking, hunting and trapping of any wildlife species, and establishing procedures for regulating the number of persons eligible to participate in such angling, taking, hunting or trapping, when the commission determines such action is necessary to maintain properly the supply of wildlife, alleviate damage to other resources, or to provide a safe and orderly recreational opportunity.

(3) Notwithstanding subsections (1) and (2) of this section, except as provided in ORS 498.146 (Shining artificial light on game mammal, predatory animal or livestock while in or near motor vehicle and while in possession of weapon restricted) or during those times and at those places prescribed by the commission for the hunting of elk, the commission shall not prescribe limitations on the times, places or amounts for the taking of predatory animals. As used in this subsection, predatory animal has the meaning for that term provided in ORS 610.002 (Predatory animals defined).

(1) No person shall remove from its natural habitat or acquire and hold in captivity any live wildlife in violation of the wildlife laws or of any rule promulgated pursuant thereto.

(2) The State Fish and Wildlife Commission may promulgate rules to carry out the provisions of subsection (1) of this section that include but are not limited to:
(a) Providing for the issuance and form of permits for the holding or removal from habitat of wildlife.

(b) Prescribing the wildlife species for which holding or habitat removal permits are required.

(c) Prescribing the terms and conditions of holding wildlife and removing wildlife from habitat to insure the humane care and treatment of the wildlife.

(3) No person to whom a wildlife holding or removal from habitat permit has been issued shall violate any of the terms or conditions thereof.

498.002  
Wildlife as state property: Taking, angling, hunting or trapping in violation of wildlife law or rules prohibited

(1) Wildlife is the property of the state. No person shall angle for, take, hunt, trap or possess, or assist another in angling for, taking, hunting, trapping or possessing any wildlife in violation of the wildlife laws or of any rule promulgated pursuant thereto.

(2) No person shall angle for, take, hunt or trap, or assist another in angling for, taking, hunting or trapping any wildlife while intentionally violating ORS 164.245 (Criminal trespass in the second degree) to 164.270 (Closure of premises to motor-propelled vehicles) or 498.120 (Hunting on another’s cultivated or enclosed land).

498.006  
Chasing or harassing wildlife prohibited

Except as the State Fish and Wildlife Commission by rule may provide otherwise, no person shall chase, harass, molest, worry or disturb any wildlife except while engaged in lawfully angling for, taking, hunting or trapping such wildlife

498.012  
Taking wildlife causing damage, posing public health risk or that is public nuisance

(1) Nothing in the wildlife laws is intended to prevent any person from taking any wildlife that is causing damage, is a public nuisance or poses a public health risk on land that the person owns or lawfully occupies. However, no person shall take, pursuant to this subsection, at a time or under circumstances when such taking is prohibited by the State Fish and Wildlife Commission, any game mammal or game bird, fur-bearing mammal or nongame wildlife species, unless the person first obtains a permit for such taking from the commission.

(2)(a) Nothing in subsection (1) of this section requires a permit for the taking of cougar, bobcat, red fox or bear pursuant to that subsection. However, any person who takes a cougar, bobcat, red fox or bear must have in possession written authority therefor from the landowner or lawful occupant of the land that complies with subsection (4) of this section.

(b) Nothing in subsection (1) of this section requires the commission to issue a permit for the taking of any wildlife species for which a U. S. Fish and Wildlife Service permit is required pursuant to the Migratory Bird Treaty Act (16 U.S.C. 703 to 711), as amended.
(3) Any person who takes, pursuant to subsection (1) of this section, any cougar, bobcat, red fox, bear, game mammal, game bird, fur-bearing mammal or wildlife species whose survival the commission determines is endangered shall immediately report the taking to a person authorized to enforce the wildlife laws, and shall dispose of the wildlife in such manner as the commission directs. In determining procedures for disposal of bear and cougar, the commission shall direct the State Department of Fish and Wildlife to first offer the animal to the landowner incurring the damage.

(4) The written authority from the landowner or lawful occupant of the land required by subsection (2) of this section for the taking of cougar, bobcat, red fox or bear must set forth all of the following:

(a) The date of issuance of the authorization;

(b) The name, address, telephone number and signature of the person granting the authorization;

(c) The name, address and telephone number of the person to whom the authorization is granted;

(d) The wildlife damage control activities to be conducted, whether for bear, cougar, red fox or bobcat; and

(e) The expiration date of the authorization, which shall be not later than one year from the date of issuance of the authorization.

(5) Any regional office of the State Department of Fish and Wildlife ordering the disposal of an animal under subsection (3) of this section shall file a report with the State Fish and Wildlife Director within 30 days after the disposal. The report shall include but need not be limited to the loss incurred, the financial impact and the disposition of the animal. The director shall compile all reports received under this subsection on a bimonthly basis. The reports compiled by the director shall be available to the public upon request.

(6) ORS 498.014 (Taking of wolves by State Department of Fish and Wildlife to address chronic depredation) governs the taking of wolves that are causing damage.

(7) As used in this section:

(a) Damage means loss of or harm inflicted on land, livestock or agricultural or forest crops.

(b) Nongame wildlife has the meaning given that term in ORS 496.375 (Nongame wildlife defined).

(c) Public nuisance means loss of or harm inflicted on gardens, ornamental plants, ornamental trees, pets, vehicles, boats, structures or other personal property.

498.022
Purchase, sale or exchange of wildlife prohibited

Except as the State Fish and Wildlife Commission by rule may provide otherwise, no person shall purchase, sell or exchange, or offer to purchase, sell or exchange any wildlife, or any part thereof.
635-110-0000
Wolf Conservation Management Plan

The document entitled "Oregon Wolf Conservation and Management Plan" dated October 2010 is incorporated here by reference as administrative rule. (This incorporation by reference includes the body of the Plan plus its Appendix A. Other appendices are excluded.) Copies may be obtained at the Salem headquarters office of the Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Drive S.E., Salem, OR 97302. This document includes program direction, objectives and strategies to fulfill management, research, and habitat needs. It is also intended as an informational document to assist resource management agencies with their wildlife program. As of January 10, 2014, those portions of the plan which authorize harassment or take of wolves are pre-empted in a portion of Oregon by the endangered status of the gray wolf under the federal Endangered Species Act. In the portion of Oregon where federal protections are reduced to a level below that of Oregon law, this plan governs harassment and take of wolves in Oregon.

Stat. Auth.: ORS 496.012, 496.138, 496.146, 496.162 & 498.012
Stats. Implemented: ORS 496.171–496.192, 497.298, 497.308, 498.002, 498.006 & 498.012

635-110-0010
Harassment and Take of Wolves during Phase I (Conservation)

NOTE: As of January 10, 2014, these rules are pre-empted in a portion of Oregon by the endangered status of the gray wolf under the federal Endangered Species Act. In the portion of Oregon where federal protections are reduced to a level below that of Oregon law, these rules govern harassment and take of wolves in Oregon.

(1) This rule describes the types of harassment and take of wolves allowed by persons outside ODFW during Phase I — (Conservation: 0–4 breeding pairs) as called for in chapter III of the Oregon Wolf Conservation and Management Plan. Other chapters of the Plan authorize ODFW to take wolves for other specified wildlife management purposes. For OAR 635-110-0010, 635-110-0020 and 635-110-0030, “livestock” means ratites, horses, mules, jackasses, cattle, llamas, alpacas, sheep, goats, swine, domesticated fowl, any fur-bearing animal bred and maintained (commercially or otherwise) within pens, cages and hutches, bison and working dogs. “Working dogs” means guarding dogs and herding dogs.

(2) Non-injurious harassment.

(a) Subject to the conditions specified in paragraph (c), the following persons may use non-injurious harassment against wolves without a permit:

(A) Livestock producers (or their agents) on land they own or lawfully occupy; or

(B) Grazing permittees legally using public land under valid livestock grazing allotments.

(b) Non-injurious harassment means scaring off a wolf (or wolves) without doing bodily harm, and includes (but is not limited to) firing shots in the air, making loud noises or otherwise confronting the wolf (or wolves).

(c) Non-injurious harassment is allowed without a permit under this rule only if:

(A) The wolf (or wolves) is in the act of testing or chasing livestock, is attempting to test or chase livestock or is in close proximity of livestock;

(B) The person encounters the wolf (or wolves) unintentionally (i.e., the person is not stalking or searching for wolves);
(C) The harassment in fact does not result in injury to the wolf (or wolves); and

(D) The harassment is reported to ODFW within 48 hours.

(d) Any non-injurious harassment that does not meet each requirement of this rule requires a permit in advance from ODFW.

(3) Non-lethal injurious harassment.

(a) Subject to the conditions specified in paragraph (c), in addition to state or state authorized agents, the following persons may use non-lethal injurious harassment against wolves by permit:

(A) Livestock producers (or their agents) on land they own or lawfully occupy;

(B) Grazing permittees legally using public land under valid livestock grazing allotments.

(b) Non-lethal injurious harassment means scaring off a wolf (or wolves) without killing but with some injury to the wolf. Wolves may be pursued (unintentional encounters are not required).

(c) Non-lethal injurious harassment is allowed by permit from ODFW only if:

(A) ODFW confirms wolf depredation on livestock or other wolf-livestock conflict in the area.

“Other wolf-livestock conflict” means loitering near, testing, chasing, or otherwise disrupting livestock;

(B) The applicant confers with ODFW to determine the most effective harassment method;

(C) ODFW considers the location of known den sites;

(D) The harassment in fact does not result in the death of a wolf;

(E) No identified circumstance exists that attracts wolf/livestock conflict; and

(F) The harassment is reported to ODFW within 48 hours.

(d) Permits for non-lethal injurious harassment remain valid for the livestock grazing season in which issued, provided the livestock operator complies with all applicable laws, including permit conditions. The agency shall inform harassment permit holders of non-lethal methods for minimizing wolf-livestock conflict and provide assistance upon request. Receiving future lethal control permits is contingent upon documentation of efforts to use non-lethal methods.

(4) Relocation. ODFW will authorize relocation by state personnel when a wolf (or wolves) becomes inadvertently involved in a situation, or is present in an area, that could result in conflict with humans or harm to the wolf, provided that ODFW has no reason to believe that the wolf actually attacked or killed livestock or pets. The relocation will be designed to prevent conflict with humans or reduce the possibility of harm to the wolf. The wolf (or wolves) would be relocated to suitable habitat at the direction of ODFW.

(5) Lethal take of wolves in the act of biting, wounding, killing or chasing livestock or working dogs.

(a) A person, or an agent as described in paragraph (b), may lethally take a wolf on land the person owns or lawfully occupies only if:

(A) The wolf is caught in the act of

(a) Biting, wounding or killing livestock or working dogs; or

(b) Chasing livestock or working dogs, if the person has first undertaken nonlethal actions as specified in 8(b)(C) and 8(c) of this rule, and the taking occurs during a time period in which ODFW has determined a situation of chronic depredation exists; and

(B) No person has used bait or taken other intentional actions to attract wolves.

(b) A landowner or lawful occupant of land may authorize an agent to enter the land for the purpose of taking wolves pursuant to 5(a) on the landowner or occupant’s behalf. The authorization must be in writing, be carried by the agent when wolves are taken, and must include:

(A) The date of issuance of the authorization;

(B) The name, address, telephone number and signature of the person granting authorization;

(C) The name, address, and telephone number of the person to whom authorization is granted; and

(D) The expiration date of the authorization, which may not be later than one year from the issuance date.
(c) Any person who takes a wolf pursuant to 5(a) and 5(b) of these rules must make all reasonable efforts to preserve the scene, not remove or disturb the wolf carcass, and report the take to ODFW within 24 hours.

(6) Lethal take to address chronic livestock depredation. ODFW may authorize its personnel or authorized agents to use lethal force on a wolf or wolves it reasonably believes are responsible for chronic depredation upon livestock where each of the conditions in subsections (7) through (10) of this rule is satisfied. ODFW shall limit lethal force to the wolf or wolves it deems necessary to address the chronic depredation situation.

(7) Conditions for Lethal Take by ODFW. ODFW’s discretionary authority for use of lethal force pursuant to this rule may be exercised if ODFW:

(a) Designates an Area of Known Wolf Activity, the boundary of which may be adjusted as new data or information become available;

(b) Upon the designation of an Area of Known Wolf Activity, coordinates in a timely manner with potentially affected livestock producers and other relevant interests to provide information on:

(A) The provisions of the Oregon Wolf Conservation & Management Plan and associated rules,

(B) The current state of knowledge of wolf behavior, management, and conservation,

(C) Procedures for documenting and reporting wolf activity to ODFW, including depredations upon livestock, and

(D) Non-lethal measures, incentives and available assistance aimed at minimizing conflicts between wolves and livestock or domestic animals in the area of known wolf activity;

(c) Confirms an incident of depredation of livestock by a wolf or wolves;

(d) Within 14 working days of ODFW’s confirmation of the first incident of depredation in an area:

(A) Designates an Area of Depredating Wolves, the boundary of which may be adjusted as new data or information become available;

(B) Concurrent with the designation of an Area of Depredating Wolves, prepares and publicly discloses an area-specific wolf-livestock conflict deterrence plan in coordination with potentially affected landowners, livestock producers and other relevant interests. The plan shall identify appropriate non-lethal measures according to which measures are likely to be most effective in a given circumstance, including the nature of the livestock operations, habitat, and landscape conditions specific to the area, as well as particular times of the year or period of livestock production. The plan shall be based on information compiled by ODFW before and/or during the planning effort on potentially successful conflict deterrence techniques, scientific research, and available financial resources and/or partnerships that may aid in the successful implementation of the plan. ODFW may update an area-specific conflict deterrence plan as new data become available.

(e) Confirms a total of at least 4 qualifying incidents of depredation of livestock within the previous 6 months by the same wolf or wolves.

(f) Issues and makes publicly available, prior to the exercise of lethal force, a written determination by the ODFW Director or director’s designee to use lethal force to address a specified situation of chronic depredation, along with supporting findings that:

(A) The conditions of Sections 7, 8, and 9 of this rule have been satisfied;

(B) Livestock producers in the Area of Depredating Wolves have worked to reduce wolf-livestock conflict and are in compliance with wolf protection laws and the conditions of any harassment or take permits.

(C) The situation of wolf depredation upon livestock in the Area of Depredating Wolves is likely to remain chronic despite the use of additional non-lethal conflict deterrence measures; and

(D) The wolf or wolves identified for removal are those ODFW believes to be associated with the qualifying depredations, the removal of which ODFW believes will decrease the risk of chronic depredation in the Area of Depredating Wolves.
(8) Qualifying Contingencies and Counting Incidents:
(a) An incident of depredation is a single event resulting in the injury or death of one or more lawfully present livestock that is reported to ODFW for investigation, and upon investigation by ODFW or its agent(s), ODFW confirms to have been caused by a wolf or group of wolves.
(b) A qualifying incident of depredation is a confirmed incident of depredation for the purposes of this rule if:
   (A) The depredation is outside of an Area of Known Wolf Activity or Area of Depredating Wolves. Only the first confirmed depredation by a wolf or wolves may count as a qualifying depredation,
   (B) In an Area of Known Wolf Activity, the landowner or lawful occupant of the land where the depredation occurred had:
      (i) At least seven days prior to the incident of depredation, removed, treated or disposed of all intentionally placed or known and reasonably accessible unnatural attractants of potential wolf-livestock conflict, such as bone or carcass piles or disposal sites, and
      (ii) Prior to and on the day of the incident of depredation, been using at least one measure ODFW deems most appropriate from non-lethal deterrence measures identified pursuant to section (7)(b)(D) to protect calving operations, nursing cattle, sheep operations, or other reasonably protectable situations, not including open range situations. Once a confirmed depredation has occurred in an Area of Known Wolf Activity and while ODFW is in the process of designating an Area of Depredating Wolves and creating an area-specific conflict deterrence plan, only one additional confirmed depredation in an area may count as a qualifying depredation under this subsection.
   (C) In an Area of Depredating Wolves, the landowner or lawful occupant of the land where the depredation occurred had:
      (i) Complied with subsection (B) of this section, and
      (ii) Prior to and on the day of the incident of depredation was implementing at least one non-lethal measure identified in the area-specific conflict deterrence plan developed under subsection (7)(d)(B) that is specific to the location, type of livestock operation, time of the year, and/or period of livestock production associated with the depredation. The conflict deterrence plan measure implemented by a landowner or lawful occupant must address wolf-livestock conflict in open range situations when that situation exists.
(c) Human presence, when used as a non-lethal measure under this rule, is presence which could reasonably be expected to deter wolf-livestock conflict under the circumstances and, regardless of the temporal requirements of sections 7(b)(B) and (C) of this rule, may be considered an appropriate non-lethal measure if it:
   (A) Occurs at a proximate time prior to and in an area proximate to a confirmed depredation as determined by ODFW, and
   (B) Indicates a timely response to wolf location information in situations of potential wolf-livestock conflict.
(9) Transparency and Public Disclosure.
(a) Except as provided in section (c) below, prior to using lethal force to address chronic wolf depredation, and in a timely fashion, ODFW shall document and make publicly available on at least its website:
   (A) The determinations and supporting findings referenced in section (7)(f) of this rule;
   (B) Information including but not limited to summaries of confirmed incidents of depredation and associated depredation investigation reports, maps of areas of known wolf activity and areas of depredating wolves, including changes and amendments to those maps, and area specific conflict deterrence plans; and
(C) Documentation of measures implemented pursuant to Section 8 of this rule. In documenting the removal of unnatural attractants and implementation of conflict deterrence measures, the Department may rely upon documented personal observation and/or written statements by the owner or lawful occupant of the land where qualifying incidents of depredation have occurred that confirm the non-lethal deterrence measures being utilized prior to and at the time of the qualifying depredation.

(b) In any signed statements and other information publicly disclosed pursuant to this section, the Department shall redact from public disclosure the personal information of landowners, lawful occupants, or other relevant individuals consistent with the Oregon public records law, ORS Chapter 192.

(c) In the case where the conditions in Section 7(f) of this rule have been met but strict compliance with the public disclosure requirements of this section cannot be accomplished without a delay that impedes ODFW’s ability to pursue an immediately available opportunity to remove the wolf or wolves it reasonably believes responsible for chronic depredation prior to another depredation event on livestock, this section is deemed satisfied if, prior to the use of lethal force, ODFW:

(A) Provides email or phone notification from the ODFW Director or designee to a list of interested stakeholders communicating the findings in Section 7(f) of this rule and the Department’s intent to pursue immediate lethal action based on those findings,

(B) Has previously documented and disclosed, on at least the agency’s website, the information referenced in subsections (a)(A)-(C) of this section with respect to all but the most recent qualifying depredation that resulted in ODFW’s determination to pursue lethal action, and

(C) Provides the remaining information referenced in subsections (a)(A)-(C) of this rule in a timely manner with respect to the most recent qualifying incident that ODFW pursues with immediate lethal action.

(10) Duration of chronic depredation lethal take authority. Take authority issued pursuant to subsection (7) expires:

(a) When the wolf or wolves identified for lethal removal have been removed by ODFW or any other party.

(b) ODFW may reinstate its take authority if ODFW confirms one additional qualifying incident of depredation within two months after the last confirmed qualifying depredation by what it believes to be a member or members of the same wolf pack and non-lethal efforts specified in Section 8 have continued to be implemented by the owner or lawful occupant of land where the additional depredation occurs;

(c) 45 days after issuance of the take authority and determination referenced in Section 7(f), unless ODFW confirms, within that time period, another qualifying incident of depredation on livestock by what it believes to be the same wolf or wolves identified for lethal removal and non-lethal efforts specified in Section 8 have continued to be implemented by the owner or lawful occupant of land where the additional depredation occurs; or

(d) If ODFW determines the wolf or wolves identified for lethal removal have left the Area of Depredating Wolves. To support this determination, data must show more than just a short-term or seasonal movement outside the area’s boundary.

(e) Except as allowed under subsections (b) and (c) of this Section, any subsequent authorization or reinstatement of take authority by the Department must comply with Sections 7 through 9 of this rule, and must be based upon at least one additional qualifying depredation.

(11) Lethal take in the case of extreme circumstances. Notwithstanding sections (7) and (8) of this rule, ODFW may authorize the use of lethal force in extreme circumstances.

(a) Extreme circumstances means:

(A) Four or more confirmed incidents of depredation of livestock by what ODFW reasonably believes to be the same wolf or wolves within seven days;
(B) ODFW determines, based on evidence it makes publicly available, that there were no intentionally placed or known and reasonably accessible unnatural attractants such as bone or carcass piles or disposal sites that contributed to the incidents of depredation, and that non-lethal measures are and will likely remain ineffective; and

(C) ODFW finds that depredation has rapidly escalated beyond the reasonable, available means of ODFW and affected livestock owners to stop additional livestock losses from occurring.

(b) A decision to utilize lethal force authority due to extreme circumstances shall be made by the ODFW director or director’s designee, accompanied by the findings and determinations required in section 11(a) made publically available on ODFW’s website, and exercised within 14 days of the determination to exercise lethal force authority under this section, or of the last confirmed depredation, whichever comes later.

Stat. Auth.: ORS 496.012, 496.138, 496.146 & 496.162
Stats. Implemented: ORS 496.171 - 496.192, 497.298, 497.308, 498.002, 498.006, 498.012 & 498.026

635-110-0020
Harassment and Take of Wolves During Phase II (Management)
NOTE: as of January 10, 2014, these rules are pre-empted in a portion of Oregon by the endangered status of the gray wolf under the federal Endangered Species Act. In the portion of Oregon where federal protections are reduced to a level below that of Oregon law, these rules govern harassment and take of wolves in Oregon.

(1) This rule describes the types of harassment and take of wolves allowed by persons outside ODFW (or ODFW or Wildlife Services acting as their agent) during Phase II — (Management: 5-7 breeding pairs) as called for in chapter III of the Oregon Wolf Conservation and Management Plan. Other chapters of the Plan authorize ODFW to take wolves for other specified wildlife management purposes.

(2) Non-injurious harassment of wolves is allowed under the same conditions as in Phase I (OAR 635-110-0010(2)).

(3) Non-lethal injurious harassment.

(a) Non-lethal injurious harassment is allowed without a permit on private land by livestock producers or their agents on land they own or lawfully occupy. Livestock producers are encouraged to use non-injurious techniques first. There must be no identified circumstance that attracts wolf-livestock conflict, and the harassment must be reported to ODFW within 48 hours.

(b) Non-lethal injurious harassment is allowed by permit on public land by grazing permittees who are legally using public land under valid livestock grazing allotments and upon the following conditions:
   (A) ODFW confirms wolf depredation on livestock or other wolf-livestock conflict in the area.
   “Other wolf-livestock conflict” means loitering near, testing, chasing, or otherwise disrupting livestock;
   (B) ODFW considers the location of known den sites;
   (C) There is no identified circumstance at the site which attracts wolf/livestock conflict; and
   (D) The harassment is reported to ODFW within 48 hours.

(c) As to non-lethal injurious harassment on either private or public land, pursuing wolves is allowed.

(4) Relocation of wolves will be considered under the same circumstances as in Phase I (OAR 635-110-0010(4)).

(5) Lethal take of wolves in the act of biting, wounding, killing or chasing livestock or working dogs.

(a) A person, or an agent as described in paragraph (b), may lethally take a wolf on land the person owns or lawfully occupies only if:
   (A) The wolf is caught in the act of biting, wounding, killing or chasing livestock or working dogs; and
   (B) No person has used bait or taken other intentional actions to attract wolves.

(b) A landowner or lawful occupant of land may authorize an agent to enter the land for the purpose of taking wolves pursuant to 5(a) on the landowner or occupant’s behalf. The authorization must be in writing, be carried by the agent when wolves are taken, and must include:
(A) The date of issuance of the authorization;
(B) The name, address, telephone number and signature of the person granting authorization;
(C) The name, address, and telephone number of the person to whom authorization is granted; and
(D) The expiration date of the authorization, which may not be later than one year from the issuance date.

(c) Any person who takes a wolf pursuant to 5(a) of these rules must make all reasonable efforts to preserve the scene, not remove or disturb the wolf carcass, and report the take to ODFW within 24 hours.

(6) Lethal take to deal with chronic depredation.
   (a) ODFW may authorize its personnel, authorized agents, or Wildlife Services, to use lethal force on wolves at a property owner or permittee’s request if:
      (A) ODFW confirms either:
           (i) Two confirmed depredations by wolves on livestock in the area; or
           (ii) One confirmed depredation followed by three attempted depredations (testing or stalking) in the area;
      (B) The requester documents unsuccessful attempts to solve the situation through non-lethal means;
      (C) No identified circumstance exists that attracts wolf-livestock conflict; and
      (D) The requester has complied with applicable laws and the conditions of any harassment or take permit.
   (b) Subject to the conditions specified in paragraph (c) and with a limited duration permit from ODFW, the following persons may use lethal force to deal with chronic depredation:
      (A) Livestock producers (or their agents) on land they own or lawfully occupy; or
      (B) Grazing permittees legally using public land.
   (c) ODFW will issue a permit to use lethal force to deal with chronic depredation only if:
      (A) ODFW confirms that the area has had at least two depredations by wolves on livestock;
      (B) ODFW determines that wolves are routinely present on that property and present a significant risk to livestock;
      (C) There is no identified circumstance at the site which attracts wolf/livestock conflict;
      (D) The applicant is in compliance with applicable laws and the terms of any previous wolf permit;
      (E) The applicant documents use of non-lethal methods; and
      (F) Any wolf taken is considered property of the state and reported to ODFW within 48 hours.
   (7) “Identified circumstance” means a condition which:
      (a) ODFW determines, based upon its investigation of the situation, attracts wolves and fosters conflict between wolves and livestock; and
      (b) ODFW advises the landowner, livestock producer or grazing permittee to remedy; but
      (c) The landowner, livestock producer or grazing permittee fails to remedy.
   (8) “In the area” means where ODFW has determined the presence of the depredating wolves.

Stat. Auth.: ORS 496.012, 496.138, 496.146 & 496.162
Stats. Implemented: ORS 496.171 - 496.192, 497.298, 497.308, 498.002, 498.006, 498.012 & 498.026

635-110-0030
Harassment and Take of Wolves during Phase III

NOTE: as of January 10, 2014, these rules are pre-empted in a portion of Oregon by the endangered status of the gray wolf under the federal Endangered Species Act. In the portion of Oregon where federal protections are reduced to a level below that of Oregon law, these rules govern harassment and take of wolves in Oregon.

(1) This rule describes the types of harassment and take of wolves allowed by persons outside ODFW (or ODFW or Wildlife Services acting as their agent) during Phase III (more than 7 packs) as
called for in chapter III of the Oregon Wolf Conservation and Management Plan. Other chapters of the Plan authorize ODFW to take wolves for other specified wildlife management purposes.

(2) Non-injurious harassment of wolves is allowed under the same conditions as in Phase I (OAR 635-110-0010(2)).

(3) Non-lethal injurious harassment is allowed under the same conditions as in Phase II (OAR 635-110-0020(3)), except that wolf depredation on livestock or other wolf-livestock conflict may be confirmed by either ODFW or Wildlife Services.

(4) Relocation of wolves will be considered under the same circumstances as in Phase I (OAR 635-110-0010(4)).

(5) Lethal take of wolves in the act of attacking livestock is allowed under the same conditions as for Phase II (OAR 635-110-0020(5)), except that wolf depredation on livestock may be confirmed by either ODFW or Wildlife Services.

(6) Lethal take of wolves to deal with chronic depredation is allowed under the same conditions as for Phase II (OAR 635-110-0020(6)), except that wolf depredation on livestock may be confirmed by either ODFW or Wildlife Services.

(7) The Commission will authorize controlled take of wolves by special permit in specific areas where necessary to address chronic wolf-livestock conflicts or ungulate population declines. "Chronic" means two livestock depredations have been confirmed by ODFW or Wildlife Services, or one depredation followed by three attempted depredations (testing or stalking). The Commission may also choose to authorize such controlled take on private lands where the landowner is willing to provide access.

Stat. Auth.: ORS 496.012, 496.138, 496.146 & 496.162
Stats. Implemented: ORS 496.171 - 496.192, 497.298, 497.308, 498.002, 498.006, 498.012 & 498.026

635-110-0040
Incidental Take of Wolves

Any person may apply for a permit to authorize take of a gray wolf (or wolves) incidental to an otherwise lawful activity, as per OAR 635-100-0170. However, ORS 496.172(4) prohibits the Commission from issuing an incidental take permit for a species that is federally listed.

Statutory authority: ORS 496.012, 496.138, 496.146, 496.162
Statutes implemented: ORS 496.171-. 496.192, 497.298, 497.308, 498.002, 498.006, 498.012, 498.026

DIVISION 002
DISPOSAL OF WILDLIFE AND EQUIPMENT SEIZED OR OTHERWISE ACQUIRED

635-002-0012
Disposal of Wildlife or Wildlife Parts

Any wildlife or parts of wildlife acquired and not otherwise specifically directed elsewhere in this Division shall be disposed of as follows: Pelts or hides of furbearing and game mammals shall be disposed of in a manner determined by the Department including use for scientific, enforcement or educational purposes. Pelts or hides may be sold.
Holding Pure-Bred Gray Wolf or Wolves in Captivity

This rule governs the holding in captivity of pure-bred wolves in Oregon, with the objective of protecting the public’s native wildlife.

(1) The only persons who may hold pure-bred wolves in captivity are those who, as of December 31, 2009, held a gray wolf or wolves in captivity under previous Oregon Department of Agriculture, Class I Exotic Canine, Exotic Animal Division 603 Rules or held a valid license or registration from the U.S. Department of Agriculture, under the federal Animal Welfare Act of 1970. These persons may hold only gray wolves, and only if they obtain authority under the requirements of paragraphs (4) or (5) of this rule.

(2) Beyond the persons described in paragraph (1), the Department will not issue any new permits to hold a pure-bred wolf in captivity.

(3) For the purpose of this rule, a wolf is considered “pure-bred” so long as it does not include any hybrid cross with a domestic dog or other canine. The Department will determine pure-bred status based on written documentation that may include breeding records, records of acquisition and disposition transactions and sworn statements.

(4) To maintain the authority to hold pure-bred gray wolves in captivity, a person described in paragraph (1) must:
   (a) No later than 30 days before the expiration date printed on the permit issued by either the Department or the Department of Agriculture which authorized the person to keep one or more wolves in captivity:
      (A) Apply to the Department for a captive wolf holding permit, using a form provided by the Department. Such permits will have a term of two years and may include, but are not limited to, conditions designed to protect native wildlife and human safety;
      (B) Pay the Department a fee of $100 (plus a $2.00 license agent fee);
      (C) Demonstrate to the Department that the person’s wolf holding facility meets the minimum special requirement standards for Class I Exotic Canines under the Oregon Department of Agriculture rules (OAR 603-011-0725) in effect as of April 1, 2010; and
      (D) Certify to the Department that the person’s wolf handling facility complies with any applicable city or county ordinances and any applicable federal laws.
   (b) Obtain written authorization from the Department before transferring a pure-bred gray wolf to another facility or releasing any pure-bred gray wolf into the wild;
   (c) Not import, export, purchase, sell or exchange any pure-bred gray wolf; and
   (d) Comply with the terms of any permit issued by the Department.

(5) Notwithstanding subparagraph (4)(a) above, a person who qualifies to hold a pure-bred gray wolf under paragraph (1) through possessing an exhibitor permit from the U.S. Department of Agriculture does not need to obtain a wolf holding permit from the Department so long as the person maintains the person’s federal permit. However, the person must still comply with the requirements of subparagraphs (4)(b) and (c).

(6) The Department may revoke a wolf holding permit if the Department determines that the person has violated these rules or the terms of the permit. If the Department proposes to revoke a person’s wolf holding permit, the person may request a contested case hearing within 14 days of notice of the proposal.
635-065-0750
Disguising Sex, Waste, and Sale

It is unlawful:

(1) To disguise the sex or kind of any wildlife while in the field or in transit from the field.

(2) To waste any game mammal or parts thereof, except that the meat of cougar is considered inedible and need not be salvaged. The hide of a cougar must be sealed and retained.

(3) To sell or offer for sale, barter, or exchange, any game mammals or parts thereof except deer, elk, and antelope hides, and shed or legally taken cervid antlers used for handcrafted items and cervid antlers which have been handcrafted as described in OAR 635-200-0050.

635-065-0760
Other Restrictions

It is unlawful:

(1) To take or hold in captivity the young of any game mammal.

(2) To hold in captivity any wildlife of this state for which a permit is required without first securing a permit.

(3) To release without a permit any wildlife brought from another state or country, or raised in captivity in this state.

(7) To take or attempt to take any game mammals, game birds, migratory waterfowl or any protected wildlife species of any size or sex or amount, by any method or weapon, during any time or in any area not prescribed in these rules.