The Hunt for the Gray Wolf:

A Case Study in Recovering Top-Predator Management Policy in Washington State

MAPS Capstone

UNIVERSITY OF WASHINGTON BOTHELL

June 2013

Authored by: Rachel Phillips

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Master of Arts in Policy Studies

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Executive Summary

Growing gray wolf populations in neighboring states have led to high dispersal into Washington State and a rapidly increasing population of wolves that den within Washington State boundaries. This growing population led to increased conflict with livestock in eastern Washington, and has sped up the gray wolf hunting policy conversation. It is imperative that for this policy to be successful, it supports the four objectives outlined by the Washington Department of Fish and Wildlife in the Washington State Gray Wolf Conservation and Management Plan from December 2011. In order to support those objectives, policies must incorporate robust science regarding the impacts of hunting on gray wolf biology and pack social structure, as well as current social attitudes around wolf management.

After being nearly extirpated from the lower 48 states by the 1930s, wolves were given protection under the Federal Endangered Species Act in 1973. Wolves began recovering in the Northern Rocky Mountain region in the 1990s, and population numbers were large enough to implement a hunting season in many of those states for the 2012-2013 gaming season. As of March 2013, there were ten confirmed packs, two suspected packs, and two border pack in Washington State.

Pack structure is crucial to wolf survival and reproductive success. The pack plays an important role in protecting and rearing pups, securing den and rendezvous sites, collectively hunting large wild prey, and passing down complex social learning. Indiscriminate hunting can negatively impact this pack structure by reducing the ability of the pack to maintain its territory often resulting in pack dissolution, increasing the survival pressure and decreasing the breeding by remaining members if alphas are removed, decreasing pup survival and leading to higher natural mortality rates, and decreasing complex generational learning crucial for individual's roles in the social structure.

These negative impacts can lead to long-term consequences in direct opposition to the four wolf management objectives outlined by the WDFW, including an increased depredation on livestock and increased wolf-human conflict, which can lead to decreased tolerance and understanding of wolf conservation and management needs by the public.

The 2008-2009 surveys of Washington State public attitudes regarding predator management and wolf recovery show that the majority of respondents support wolf recovery (75%), while also supporting some form of lethal management to protect at-risk livestock and ungulate populations (61%). Wolves do not negatively impact ungulate populations at a significant level. Conflict-preventative measures have proven successful in deterring wolf-livestock conflict.

This paper outlines six policy recommendations to the WDFW for wolf hunting policy; all of which support the objectives in the management plan: (1) Inclusion of a scientific panel; (2) Designated hunting zones with buffer zones; (3) Responsible restrictions; (4) Manage above minimum target recovery levels; (5) Agency resources favor non-lethal preventative measures; and (6) Policy formation is a collaborative process.

Inclusion of a scientific panel: Predator management and hunting wolves are polarizing issues. To help ensure public support of a limited wolf hunt in WA State, a scientific panel is crucial for legitimacy in the process. A scientific panel will offer robust science needed to inform policy, legitimacy needed for public support of that policy, and the foundation for public education needed for tolerance and understanding.

Designated hunting zones and buffer zones: Designating specific areas as "no wolf hunting" and "hunting" zones provide a variety of conservation and public relations advantages. No-hunting zones would be areas of high habitat value where wolves are likely to den and rear pups. Wolf-free zones would be areas of low habitat value where conflict with livestock is likely higher. Buffer zones around no-hunting zones help protect den and rendezvous sites.

Responsible restrictions: Holding the season from November to January 31 helps ensure pups have reached adult size and females have not yet conceived, aiding in public backlash about hunting young pups or pregnant females. Bag limits help ensure a responsible number of wolves are taken and the population is not over-hunted. The recommended bag limit per person is one.

Manage above minimum recovery levels: Managing above minimum recovery levels helps account for unforeseen environmental conditions that can negatively impact the population (poor breeding or hunting season, disease). The WDFW intends to manage above 15 breeding pairs distributed statewide. This policy should be upheld as it is informed by science.

Resources favor preventative measures: The WDFW has seen preliminary success with non-lethal preventative measures (fladry lines, range riders) and should continue these efforts. The best way to manage conflict is to prevent such conflict from happening. SB 5193 ensures a source of funds for such measures, and will be crucial in managing conflict.

Policy is collaborative process: The variety and number of stakeholders involved in this issue require a collaborative approach to policy-making. Successful environmental policy not only incorporates robust science but rigid stakeholder involvement to ensure every voice is heard. For these policies to be acceptable and successful, it is critical that stakeholder values and opinions be included in the process.

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Abstract

Gray wolf recovery in WA State is happening more quickly than originally anticipated. In May of 2011, gray wolves were delisted federally in the eastern third of Washington State, leaving those packs under the management of the Washington Department of Fish and Wildlife. Once gray wolves statewide reach recovery goals, the species will be delisted from state endangered status and relisted as a game species, resulting in a public hunting season. To ensure continued persistence of wolves in Washington State, it is imperative that a hunting plan is carefully designed with the best available science and is adaptive to policy needs. This qualitative case study examines the impacts of hunting on wolf pack social structure while accounting for current public attitudes about wolf management to make policy recommendations for the future hunting season. This study operates on the assumption that the gray wolf recovery and management objectives outlined by the WDFW are acceptable. Hunting wolves can lead to dissolution of territories, decreased pup survival, and decreased generational learning, and potentially negative population trends over time. These impacts can lead to increased depredation on livestock, increased wolf-human conflict. Current social attitudes demonstrate support for wolf recovery and minimal lethal management. Based on gray wolf biology and pack structure, public opinion polls, there are six policy recommendations to ensure the goals of the WDFW are supported with regard to wolf recovery: (1) inclusion of a scientific panel, (2) designated hunting zones; buffer zones, (3) responsible restrictions, (4) manage above minimum target recovery levels, (5) agency resources favor non-lethal preventative measures, and (6) wolf hunting policy formation is a collaborative process.

Key Words: gray wolf, hunting policy, conservation, wildlife management, gray wolves in Washington State, predator management

Chapter One: Introduction

Gray wolves were seen as a danger to livestock, competition for wild ungulates, and a pest in the US in the mid-late nineteenth century, and were all but extirpated from the lower 48 states through hunting, trapping, poisoning, and the use of bounties (Wiles 2011). After being placed under the protection of the Endangered Species Act in 1973, wolf populations began recovering in the Northern Rocky Mountain states (Wiles 2011). These growing populations dispersed into Washington State, increasing to nine established packs and at least 51 individuals in February 2013 (Wiles 2011, WDFW 2013). As a result of the population growth in the region, federal protections for wolves were removed in the Northern Rocky Mountain region, including the Eastern third of Washington State, leaving management of wolves to the state. Wolves in Eastern Washington are managed by the Washington Department of Fish and Wildlife (WDFW).

Predator species (e.g. wolves, cougars, bears) have often been managed with a public hunt; this can increase landowner tolerance and generate money for continued conservation efforts through permits and licenses (Conover 2001). However, harvesting newly recovered predator populations presents a variety of conservation issues including the impacts to population viability, overharvesting that could lead to relisting the species and requiring protections, controversy surrounding the hunt, and the politics of management. In severe conditions, irresponsible harvesting could lead to extirpation of the species (Wiles 2011).

It is expected that once wolf populations in Washington reach target recovery levels set by the WDFW, they will be removed from protections and reclassified as a game species (Wiles 2011). In anticipation of this development, this study aims to identify the likely impacts of a public hunting season to gray wolf pack structure, a crucial element to gray wolf survival and

reproductive success. In addition, this study assesses current public attitudes and stakeholder values about gray wolf recovery and management, as stakeholder participation in the policy-making process is critical to create and implement successful policies that will support the WDFW's objectives for gray wolf recovery.

Chapter Two: Gray Wolf Ecology and Management History

Gray Wolf Biology

Gray wolves (*Canis lupus*) are a top-predator species capable of inhabiting nearly every ecosystem except tropical rainforest and arid desert (Wiles 2011). Areas of high habitat value range from the northern east coast to the northern west coast, throughout Canada, and south to New Mexico and Texas (Figure 1). They are the largest wild canid in North America, ranging from five to six feet long and weighing from 60-175 pounds; their diet consists mostly of large ungulate species such as deer, elk, caribou, and moose for survival (USFWS 2006).

Gray wolves are a pack species, with social structure playing a crucial role in population growth and success (Wallach 2009). According to Mech and Boitani (2003) a pack is defined as four to eleven members consisting of the breeding alpha pair, their adult offspring, young from the previous year (yearlings), pups from the current year (pups), and any other adult-sized members not related to the family (Mech and Boitani 2003).

Female wolves reach reproductive age at approximately two years, however most females do not mate until the age of four or five (Mech 2001). Typical pack structure consists of one breeding pair, the alpha pair, and their offspring and other adult members. The alpha pair mate in January or February and the female gives birth in the spring to an average of four pups after a gestation period of 63 days (USFWS 2006). Pups stay in the den for three to five weeks while they nurse. When they are about five to eight weeks old, pups are moved to a rendezvous site, an area of about 1000 square meters (1200 square yards), that serves as a meeting place for the adult wolves and a home for the pups until they can go on hunts (Pitt 2003). During this time the pups gradually learn about their pack's hierarchy and their own place within it (Pitt 2003). Both male

and female wolves disperse from their natal pack at an average age of two to three years (Boyd 1999).

All members of the pack play an active role in the success of the group through the rearing of pups, securing food through hunting, and passing down complex learned behavior to the youngest members (Pitt 2003). Non-breeding adults either stay at the den or rendezvous site to protect and rear pups while the alphas hunt, or they hunt for food while the alpha pair protects the pups (Brainerd 2008). All members or sub groups hunt as a pack before pups disperse to provide adequate food, and incorporate pups into the hunting process as they age. All members are responsible for teaching social and hunting behavior (Brainerd 2008).

Gray Wolves and the Ecosystem

Gray wolves are considered a keystone species, with a disproportionate influence on its environment relative to its abundance (Wiles 2011). In some cases, wolves control ungulate populations such as deer, elk, and moose (Boyd 1999). These species can drastically alter the vegetative landscape, eroding stream banks and destroying crucial habitat; as wolves hunt these ungulates and population numbers are controlled, stream bank habitats are able to recover (Mech 2001).

Wolf predation also alters prey behavior causing ungulates to avoid open riparian areas where they are more vulnerable than in thicker cover. In Yellowstone National Park, wolf predation on elk aided in the recovery of over-browsed areas and new tree growth suppressed by grazing elk (Halofsky 2008). These naturally restored habitats are critical to a number of species, including salmon and native fish, waterfowl and songbirds, small riparian mammals such as beavers and muskrats, and insects (Ripple 2006). Improved habitat for these species means

overall improved functionality of the stream through water filtration and quality of habitat (Ripple 2006). The availability of more mature woody plant material in areas previously over-grazed by elk increases beaver activity, leading to greater flood control, and restriction of in-stream nutrient and pesticide/herbicide levels, improving the overall water quality of the stream (Ripple 2006).

Additionally, wolves typically hunt the small, old, weak or diseased members of ungulate herds, helping to reduce the spread of disease and reduce prey numbers, ultimately improving the overall fitness of the ungulate population (Mech 2001).

Wolves benefit native scavengers such as eagles, bears and ravens by providing a crucial source of protein, in the form of prey carcasses, especially in winter months (Stahler 2002). The introduction of wolves into the ecosystem may help buffer the impacts of climate change by providing a food source in winter months as warmer weather patterns are contributing to a decrease in natural mortality of larger animals (Wilmar 2005). Studies also show a negative relationship with coyote and wolf densities, supporting the hypothesis that increased competition between wolf and coyote populations leads to a decrease in coyote numbers (Berger 2007). This decrease in coyote numbers can lead to an increase in bird and small mammal populations, thus increasing prey for species reliant on birds and small mammals for survival (Licht 2010). In short, without apex predators such as wolves, ecosystems become generally more simplified and less diverse (Berger 2007).

History of Gray Wolves in the United States

Gray wolves once occupied much of Northern America. The monetary value of wolf pelts and depredation on livestock were motivators to hunt, trap, or poison the species. In addition,

wolves were seen as competition for ungulate species such as deer and elk, and were therefore even more unpopular (Wiles 2011). Local governments placed bounties on wolves to help expedite their removal (Wiles 2011). By the early twentieth century, gray wolves were nearly extirpated from the lower 48 states (Wiles 2011). By the 1930s, wolves were completely extirpated from Washington State. The species was listed as federally endangered in 1963 and placed under the protection of the Endangered Species Act (ESA) in 1973 in the lower 48 states (Wiles 2011). Wolves were official declared endangered under Washington State law in 1980 (Wiles 2011).

Since the mid-1980s wolf numbers have increased in Montana, Idaho and Wyoming, to more than 1,600 animals in 240 recognized packs by 2010 (Wiles 2011). In 1987, the US Fish and Wildlife Service (USFWS) required the creation of the Northern Rocky Mountain Wolf Recovery Plan, which included Idaho, Montana and Wyoming. In 1995-1996, wolves were reintroduced to Yellowstone National Park and Central Idaho by the USFWS; population growth from these reintroductions allowed wolves to meet the USFWS biological recovery goals (equitably distributed wolf population containing at least 300 wolves and 30 breeding pairs in 3 recovery areas within MT, ID, and WY for at least 3 consecutive years) in 2002 (Wiles 2011). In 2007, USFWS designated the Northern Rocky Mountain (NRM) distinct population segment (DPS) as a genetically distinct segment of gray wolves, stretching from the Canadian border through Montana and Idaho.

Though Washington was not required to submit a state wolf management plan with ID, MT and WY in 2007, the Eastern third of Washington State and Oregon was included in the designation of the NRM DPS to account for dispersing wolves from neighboring states (Figure 2) (Wiles 2011). In May of 2011, the USFWS federally delisted gray wolves in the Eastern third

of Washington State, leaving those packs under the management of Washington Department of Fish and Wildlife (Figure 3) (Wiles 2011).

Current Status

As of 2011, no federal wolf recovery objectives exist in Washington State; however USFWS has planned a status review of wolves in the Pacific Northwest, including Oregon, California and Washington (Wiles 2011). The review aims to determine if another distinct population segment exists in the northwest. If so, that DPS will be designated and a federal recovery plan will be developed (Wiles 2011). However, wolves in the Eastern third of Washington State are under the management of the WDFW, which per WAC 232-12-297 required the creation of a management plan.

Washington Department of Fish and Wildlife completed and the Washington Fish and Wildlife Commission unanimously adopted the Washington State Gray Wolf Conservation and Management Plan in December 2011 with the purpose of ensuring "reestablishment of a self-sustaining population of gray wolves in Washington and to encourage social tolerance for the species by addressing and reducing conflicts" (Wiles 2011). The plan outlines the conservation goals and management objectives for recovering gray wolf populations in the Eastern third of the state, and future wolf populations statewide, as well as the population requirements necessary for down-listing and delisting the species statewide (Wiles 2011). The WDFW states that once the wolf population reaches 15 breeding pairs distributed statewide for three years or 18 breeding pairs distributed statewide for one year, the agency can remove state protections (Wiles 2011).

In response to the removal of wolves from federal protections and the need for a state management plan for wolf recovery and management, the director of the WDFW established the

Wolf Working Group, an eighteen-member group of citizens representing livestock/agriculture, local government, conversation groups, biologists, the timber industry, hunters and outdoor enthusiasts (WDFW 2007). The goal of the group is to guide the WDFW in developing a management plan for wolves in Washington State (WDFW 2007). Using current scientific knowledge about wolves, wolf population viability information, and discussion between the Wolf Working Group and WDFW, with input and final approval from the Washington State Fish and Wildlife Commission, four wolf recovery goals were developed:

> "(1) Restore the wolf population in WA to a self-sustaining size and geographical distribution that will result in wolves having a high probability of persistence in the foreseeable future (>50-100 years); (2) manage wolf-livestock conflicts to minimize livestock loss while simultaneously avoiding negative impact to the recovery or long-term perpetuation of a sustainable wolf population in WA State; (3) maintain healthy ungulate populations that provide abundant prey for wolves and other predators, as well as harvest opportunities for hunters; and (4) to develop public understanding of the conservation and management needs of gray wolves in WA, and to promote the public's co-existence with the species" (Wiles 2011).

The Gray Wolf Management Plan outlines three recovery zones in Washington State: Southern Cascades and Northwest Coast, Northern Cascades, and Eastern Washington, created by WDFW to achieve distribution across a significant portion of the species' historic range (Figure 3) (Wiles 2011). WDFW states that once gray wolves reach recovery goals of 15 breeding pairs distributed statewide for three years or 18 breeding pairs distributed statewide for one year, the species will be delisted statewide from protected status and managed as a game species, resulting in a public hunting season.

As of March 2013, there were ten confirmed packs (packs with collared wolves and estimated pack range), two suspected packs (no collared wolves but the level of wolf activity is consistent with the existence of a pack), and two border pack (a pack that has territory in WA but dens outside WA borders) in Washington State (Figure 3) (WDFW 2013). However these

fourteen packs are only located in two of the three recovery regions, with nine packs in the Eastern Washington recovery zone, three packs in the Northern Cascades region, and no packs in the Southern Cascades recovery region (WDFW 2013).

The WDFW management plan states, "after delisting, it is anticipated that the WDFW would recommend listing [wolves] as a game species" (Wiles 2011). The plan goes on to outline the proposed processes for establishing a public hunting season for wolves, including a series of public hearings to address diverse public values and concerns (Wiles 2011). A hunting season would be based on science and literature, and would be flexible enough to account for changes in wolf population numbers; the management plan outlines the process for relisting should wolf numbers fall below recovery levels (Wiles 2011). If a public hunting season were approved while wolf population numbers were still relatively low, it is anticipated that a conservative approach would be used initially (Wiles 2011).

Wolves have established a presence in local tribal lands of Washington as well. The tribes in eastern Washington such as the Colville, Kalispel and Spokane tribes are situated directly in areas of high gray wolf recovery (Figure 4). As of December 2012, wolves were prominent on the Colville Indian Reservation, and the tribe implemented a hunting season on its lands (Figure 5).

Implications of Reclassifying Wolves as a Game Species

With gray wolf populations recovering in Washington State, it is anticipated that the WDFW will remove protections and list the species as game as a means of achieving its wolf management goals (Wiles 2011). In states with wolf hunting seasons, wolves are typically hunted from late fall to very early spring (October to February), with most hunters taking one

wolf as they can be difficult to track and tend to avoid humans (Gude 2012). Since wolves are not hunted for meat, but trophies, if given the opportunity hunters will typically aim for the largest wolf, however since they can be difficult to find initially, in many cases hunters do not discriminate for size. Distinguishing gender and alpha or non-alpha status adults is nearly impossible in the field, and therefore wolves are taken indiscriminately (Gude 2012).

Public wolf hunting is indiscriminate (without discriminating for gender, age, or status), as identifying distinguishable characteristics is near impossible until after the wolf is dead (Haber 1996, Gude 2012). The dangers of indiscriminately hunting a species are the unknown consequences for lethally removing specific members (i.e. the alpha or breeding members of the pack).

Indiscriminate hunting of wolves could, as research suggests, lead to increased conflicts with livestock and pets, as well as negatively impact the social structure of wolf pack (J. Minbashian, personal communication, October 20, 2012). In addition, Washington State has poor connectivity between high quality habitats (between the NE and North Cascades, South Cascades and Olympics, and the isolated Blue Mountains), and indiscriminate hunting could delay wolf recovery in these more difficult areas (J. Minbashian, personal communication, October 20, 2012).

Given the potential problems associated with the use of public hunting as a wolf management tool, it is imperative that before a hunting plan is put in place, it is carefully informed by the best scientific information, incorporates robust public input and stakeholder vales, and is adaptive and flexible to accommodate for changing science and viewpoints.

Research question

Based on the current status of gray wolves in WA State, and the anticipation of a public hunting season in the next few years, it is crucial that the following question be addressed:

> How can existing information on wolf ecology and public attitudes about wolf recovery and management be used to inform Washington's wolf hunting policy such that the policies are likely to achieve wolf conservation, reduce wolf-human conflicts, and enhance stakeholder support?

Chapter Three: Methodology

To examine the impacts of hunting on gray wolf pack social structure, I conducted a comprehensive literature review focused on the biology of gray wolf survival and the social factors of gray wolf pack structure. The first part of the literature review used peer-reviewed, science-based studies to determine the role of the pack in wolf survival and reproductive success. I brought all these together to provide a holistic picture of gray wolf pack structure and the importance of that structure for wolf population persistence.

The second part of this review focused on the impact of hunting on pack structure. I reviewed scientific articles describing the likely impacts of hunting, and the potential longer-term consequences of those impacts for wolf survival and management implications. I combined these studies to inform the first part of my *findings* section, and help provide an overall, as well as more detailed view of the possible impacts to pack structure and the implications of those impacts to wolf management.

To analyze the current social climate, I peer-reviewed literature in conjunction with public opinion surveys from the WDFW and other studies to create a picture of public attitudes surrounding predator management in general and wolf recovery and management more specifically. I assessed peer-reviewed literature to determine the factors that more generally influence public attitudes about predator management and hunting season. The public opinion surveys, both from WA State internationally, were used to create a more statistically based argument about public opinions in WA State and more generally.

I also reviewed newspaper articles and tribal websites to assess tribal opinions on wolf management in Washington State for the purposes of policy recommendations near those regions. I assessed current gray wolf hunting seasons in states with populations at or above target

population levels via media reports to discern the controversy around management policy issues, with the goal of Washington State learning from these neighboring states' successful and less successful policies. To better inform the policy recommendations to the WDFW, I also conducted a literature review on the use of science in policymaking.

I used all of these literature reviews and reviews of public opinion surveys to recommend policies to the WDFW concerning gray wolf hunting policy. It is important that these policies promote both gray wolf recovery and responsible management, and acceptance by all stakeholders involved. This study is operating under the assumption that these objectives (outlined in the following paragraph) are defensible and acceptable, and these are the objectives to which the policy recommendations in this paper aim to support.

Chapter Four: Literature Review and Findings

Impacts of Hunting on Pack Social Structure

Gray wolf pack social structure is crucial for population growth and success in hunting and raising pups (Wallach 2009). According to Wallach (2009), packs hunt, eat, rear pups, travel, and pass down complex learned behaviors together. Each pack member plays an important role in securing food, locating potential den and rendezvous sites and the survival and rearing of pups (Wallach 2009). Individual wolves contribute to all areas of pack survival. The alpha pair is responsible for breeding, identifying prey and den sites, and directing the pack's movement (Wallach 2009). The adult non-alpha members help rear pups while the alphas hunt, or hunt while the alphas remain at the den. In addition, adult non-alphas help to locate rendezvous sites used by the pack while pups are still young and require protection (Wallach 2009). All adult/young adult members aid in hunting, as cohesive wolf packs hunt together, allowing them to take down large prey such as elk or moose (Wallach 2009).

Public hunting has the potential to negatively effect pack social structure in four ways: (1) reduced ability to maintain territory; (2) increased survival pressure/decreased breeding by remaining members; (3) decreased pup survival/higher natural mortality rates; and (4) decreased generational learning of complex social behaviors (Creel 2010, Rutledge 2010). These impacts can lead to a variety of potentially negative influences on pack structure, and subsequently to broader consequences beyond the individual pack such as increased depredation on livestock; therefore reinforcing the need for scientifically based hunting policy.

Reduced ability to maintain territory

Increased human-caused wolf mortality can lead to a reduced ability by the remaining pack members to maintain territory boundaries (Harrington 1979). The loss of one or both breeders in a pack can result in the dissolution of territory boundary lines and more variable territory size (Rutledge 2010). It also can lead to the breakup of the pack, leaving remaining members in a partial pack. A study by Creel (2010) found 38% of packs dissolved after the loss of a breeder (Creel 2010). In addition, fewer packs dissolved where breeding members remained, and in 40% of cases, removing breeding members disrupted packs and remaining wolves abandoned their territory (Brainerd 2008). These partial packs often travel to new territories, invading other packs, potentially increasing competition or disrupting intact packs (Ballard 1987). Remaining wolves, known as lone wolves once they abandon their territory and move to a new location alone, can have negative impacts on intact packs in the area (Rutledge 2010). Inter-pack conflict over territory boundaries or intrusion by lone wolves can lead to the death of pack members (Harrington 1979).

Verdade (1996) observed a break up of social structure after dissolution of the pack, amplifying impacts of human-caused mortality (Verdade 1996). Maintaining kin relationships in socially complex animals can have positive effects on fitness and resource use; and the adoption of unrelated individuals into genetically related packs can lead to increased competition (Rutledge 2010). Additionally, Rutledge cites higher reproductive success and lower stress hormones in wolves in intact packs compared to those in unrelated groups socially disrupted by poaching (Rutledge 2010).

Dissolution of a pack can result in increased wolf-livestock conflict, decreased pack size, and increased wolf-human conflict as lone wolves search new territories (Verdade 1996). These

impacts lead to increased competition among remaining wolves; resulting in increased depredation on livestock as lone wolves must resort to hunting easier prey than when the pack hunted as a unit (Brainerd 2008). This increased wolf-human and wolf-livestock conflict can lead to negative public attitudes toward wolf recovery and a lack of motivation by landowners to engage in conflict-prevention measures (Rutledge 2010). Finally, dissolution of the pack can lead to amplified human or natural-caused mortality as packs become smaller and stronger members are lost (Brainerd 2008).

Increased survival pressure/decreased breeding by remaining members

The loss of an alpha member can lead to decreased breeding by the remaining members of the pack. In one case, gray wolves only reproduced in 47% of cases following the loss of a breeder (Brainerd 2008). However, a greater portion of remaining wolves reproduced when only one breeder had to be replaced compared to the loss of both breeders, indicating that packs faired better where at least one breeder remained (Brainerd 2008). Creel (2010) found that only 9% reproduced in the year after the loss of both breeders (Creel 2010). Reproduction suppression leads to overall smaller pack size, making the recovery time to replace breeders much longer as overall populations are smaller (Brainerd 2008). Intervals for alpha replacement were shorter in established wolf populations relative to new, recolonizing populations (Brainerd 2003). For recolonizing wolves, population size was inversely correlated with time intervals for alpha replacement, suggesting that more established populations take less time to replace alpha members (Brainerd 2003).

As adult-sized members are lost through hunting, the average age of the pack decreases. This leaves younger, less experienced members in more critical positions usually occupied by

older, more mature individuals (Rutledge 2010). In addition, young members require more prey biomass than adults for growth and maturation; as the overall age structure of the pack decreases, the demand for more food can increase (Wallach 2009). This, combined with fewer adult pack members, leads to fewer individuals available to rear pups and greater pressure on remaining adults to find food (Brainerd 2008). Finally, young pups reduce the mobility of the pack, creating a greater need to find food nearby, and thus potentially contributing to an increase in livestock depredations in areas near livestock grazing (Brainerd 2008).

Decreased breeding coupled with increased pressure to find food and rear pups can lead to increased depredation on livestock, as wolves search for easier prey to feed the remaining members (Wallach 2009). The ability of these smaller, pressured packs to maintain sustainable numbers in the population may be hindered (Creel 2010).

Decreased pup survival/higher natural mortality rates

Harvesting gray wolves can lead to decreased pup survival as more members are eliminated (Brainerd 2008). Due to the fact that non-breeders either rear pups while alpha members hunt, or vice versa, the loss of any adult members of the pack can lead to reduced care of pups (Brainerd 2008). In a study of wolves in Alaska, the Northern Rocky Mountains, Wisconsin, Greece, and Scandinavia, the number of adult-sized wolves left after breeder loss had the largest impact on pup survival, and pup survival was greater in groups of six members or more (Brainerd 2008). In groups of 3-5 wolves, more than one pup survived in 81% of cases; versus more than 97% in groups of six wolves or more (Brainerd 2003).

A study conducted by Mech (1975) observed a decrease in care of young as packs were hunted and members killed, resulting in higher pup mortality (Verdade 1996). Ecological factors

such as prey availability, coupled with the loss of key pack members, can affect the ability or willingness of various pack members to provide food or other care for pups (Harrington 1983).

Fewer adult pack members results in less care for young and fewer members to hunt. This can result in higher mortality rates in populations being exploited as pack sizes become smaller, home territories are less stable and occupied at more variable times, and the overall age of the population is younger (Rutledge 2010). Finally, higher natural mortality rates (disease, environmental factors) and a decrease in pup survival can result in reduced numbers of wolves surviving reproductive age (Rutledge 2010).

Overall younger age structure can lead to increased depredations on livestock and increased wolf-human conflict (Rutledge 2010, Wallach 2009). Younger members lack experience hunting wild prey, and general stress on the pack through loss of adults and pups can cause reliance on livestock (Rutledge 2010). These consequences can lead to a lack of tolerance of wolves by the public, negative cultural attitudes towards wolf recovery, and demotivation to learn to live with wolves.

Decreased generational learning of complex social behaviors

Gray wolf pack structure is an important part of the generational learning of complex social behaviors (Wallach 2009). Gray wolves pass down complex behaviors to younger generations. These behaviors can include various pack roles, hunting practices, the process of locating den and rendezvous sites, and interactions with other packs (Haber 1996). The removal of alpha or nanny wolves through harvest or lethal control can lead a loss of this generational learning, and an eventual simplification of and diminished role for these complex behaviors (Wallach 2009).

This impact carries a number of consequences; first, a less effective use of resources by younger generations as complex hunting behaviors are simplified or lost (Haber 1996). In addition, intact packs engage in group hunting before the pups disperse, teaching both social and hunting behaviors through parents and adult-aged members (Wallach 2009). When member loss through harvest or lethal control occurs, these lessons can be lost, and so can the effective use of resources (Wallach 2009).

Loss of complex learned social behaviors can lead to an increase in depredation on local livestock as younger members who are lacking complex hunting techniques look for more convenient food sources (Haber 1996). In addition, if livestock is available during critical times (i.e. during times of high hunting rates, particularly harsh winters, etc.), this likelihood of livestock depredation increases (Haber 1996).

Wolves' Impacts on Ungulate Populations

The 2008 survey indicated a sizeable minority, 42% of respondents, support hunting for this reason, supporting the argument that wolf hunting should not be primarily a management tool for ungulate populations, and that policies surrounding this issue should be based on the latest science to both provide accurate population data as well as legitimacy to the public.

Recent studies on ungulate populations in states with increasing wolf populations have found that while wolf predation has accounted for slight declines in ungulate population numbers, the "effect of wolf predation on ungulate populations and subsequent hunter harvest appears minor and difficult to detect" (Bangs 2005). In addition, those declines can also be attributed to a variety of other factors (Smith et al 2011). These factors can include other predators, foraging availability, reproductive success, and other environmental or human-caused

factors (Smith et al 2011). Wolf predation on elk herds actually improved the overall fitness of the herd; reductions in numbers lead to higher biomass ratios for the remaining herd members, therefore providing better nutrition (Wilmar and Getz 2004).

Mule deer in Montana have shown an increasing trend since 1995, despite the recovery wolf population (Hamlin and Cunningham 2009). Although moose count and calf numbers have declined in Montana since the late 1980s, this decline was before wolf restoration, and therefore cannot be attributed to growing wolf populations (Hamlin and Cunningham 2009).

More generally, though wild ungulates are the main source of food for gray wolves, and wolves have caused slight declines in wild ungulate population numbers since their restoration, these declines are not significant enough to impact harvest levels for hunters (Smith et al 2011). Wolves have been known to gain nutrients from other sources when wild ungulates are not easily available, even salmon or robust vegetation (Meriggi 1996, Darimont 2003). It is crucial that if wolf-ungulate conflict does exist in Washington State, a public hunting season should not be used to manage that conflict, as it is not widely supported by the public and is not supported by science.

Preliminary Research – Wolf Hunting in Montana

The University of Montana, in conjunction with the Montana Cooperative Wildlife Research Unit is currently conducting a study on the impacts of increased human-caused mortality on gray wolves in the Rocky Mountains (Ausband 2012). States in the Rocky Mountain range have recently initiated wolf hunting seasons; this study aims to record the impacts of hunting on gray wolf pack structure, and the overall short-term and long-term impacts on wolves of increased human-caused mortality (Ausband 2012).

Preliminary modeling of wolf populations demonstrates that established packs (existing ≥ 3 years) have a higher survival rate than emerging packs, most notably during periods characterized by high competition between packs (Ausband 2012). Preliminary results also indicate a significant difference in survival between established packs and emerging packs (Ausband 2012). These results lend support to the hypothesis that established packs are important for continued wolf population growth and persistence (Ausband 2012).

Finally, preliminary analyses of satellite collar data indicates that gender of the helper wolves does matter; female helpers contribute more to pup-guarding and rearing duties than male helpers (Ausband 2012). Changes to pack composition may affect the ability of packs to adequately guard and rear young (Ausband 2012). This preliminary finding suggests that hunting individuals without regard to age or gender could negatively impact that pack's ability to rear or protect its young, and could ultimately lead to increased pup mortality.

Conclusion

Reduced ability to maintain territory, decreased pup survival, increased survival pressure, decreased breeding by remaining members, and decreased generational learning are all potential impacts to wolf social structure (Rutledge 2010). These impacts also have the potential to lead to consequences counterproductive to the WDFW's management objectives, such as decreased wolf populations and increased depredation on livestock, which can lead to decreased public tolerance. Though the research is limited on these impacts and potential consequences, preliminary studies indicate that increased depredation on livestock is the most likely result of overharvesting (Rutledge 2010).

Additionally, social predators may have a greater risk of extinction when harvested due to reproduction suppression after member loss (Creel 2010). This highlights the fine line between human-caused mortality as compensatory (balanced with natural mortality) or additive (in addition to natural mortality) in the case of hunting social predators. While the majority of research indicates that human-caused mortality is compensatory, the potential exists for hunting to be additive under certain conditions (Creel 2010). This may be the case with wolves as the largest adults are desired for trophy hunting, and therefore their if hunters are able to choose their target among several wolves, their loss could have the largest impact on social dynamics (Rutledge 2010).

Though wolves have shown slight impacts on ungulate populations in areas of high wolf recovery, these impacts are not significant enough to impact harvest opportunities (Smith et al. 2010). Preliminary data suggests that the removal of sheer numbers of wolves at a manageable level does not negatively impact populations overall (Rutledge 2010). However, the importance of social structure to wolf survival and reproductive success, and the potential negative impacts of indiscriminate hunting on that social structure indicate that recovering wolf populations may not be able to withstand what would otherwise be considered a bearable level of hunting (Rutledge 2010).

Public Attitudes and Stakeholder Values

Public attitudes and stakeholder values are important in polarizing issues like predator management to ensure that policies are acceptable to all stakeholders. The public opinion surveys conducted in Washington State regarding predator management offer insight into

Washingtonians' views on wolf recovery and a public hunting season and provide valuable information for developing a wolf management policy that is acceptable as well as effective.

WDFW Public Opinion Surveys

Washington State public attitudes towards wolf recovery, management and hunting were documented in four studies conducted in 2008 and 2009 (Wiles 2011). The statistics presented in this paper represent survey questions whose responses are related to wolf management policies in Washington State, and will be beneficial to the WDFW. The first survey was a 2008 study in which 805 residents 18 years old or older were surveyed via telephone statewide. According to the study, 75% of WA residents support wolf recovery, and only 17% oppose (Duda et al. 2008a). Those numbers changed to 61% in favor and 28% opposed when respondents were asked to consider the potential decline of elk and deer populations if wolf populations increased (Duda et al. 2008a).

The survey also found that 61% of respondents support some form of lethal control of wolves to protect at-risk livestock, and 31% oppose. When specifically asked about hunting as a management tool, 46% of respondents supported hunting to address human-wildlife conflict, while 39% were opposed. Likewise, more respondents supported (50%) than opposed (43%) the use of hunting to reduce predator populations, and 42% of respondents supported hunting of predators to increase game populations (Duda et al. 2008a).

The second survey surveyed 931 hunters age 12 and older in WA State via telephone about wildlife management, and wolves specifically (Wiles 2011). Though the survey did not report specific statistics regarding wolves, support for managing wolves to a self-sustaining population exceeded opposition in all categories of hunters except one (sheep/moose/goat

hunters); however the reasons for this support varied from "all wildlife deserving the right flourish" to necessary management so wolves do not overpopulate (Duda et al. 2008b). Opposition to wolf recovery and management came from fear of livestock depredation, competition for ungulate species, or a desire to not have wolves in the area (Duda et al. 2008b).

The third survey, conducted by Colorado State University and the WDFW in fall 2009, assessed public opinion on wolf management through 4,183 mail-in responses statewide (Wiles 2011). Respondents demonstrated high support for natural wolf re-colonization (74.5%), but also a high level of support (63.5%) for hunting if wolves have exceeded recovery goals (Dietsch et al. 2011).

The fourth survey, conducted in 2009, used 325 statewide mail-in responses about wolf management policies (Wiles 2011). The survey found majority support (55.7%) for a collaborative policy-making process (Callahan 2011). Additionally, 36.9% supported managing wolves through hunting; however 48.3% felt the best management method of wolves is public education on how to live with wolves (Callahan 2011).

These studies demonstrate overall support for wolf recovery and responsible management, with 75% of Washington residents in favor of wolf re-colonization. However, public opinion also supports (~62%) a limited public hunting season to help manage wolf population numbers and conflict with livestock (Wiles 2011).

National/International Public Attitudes Surveys

Williams et al. (2002), analyzed 37 quantitative surveys on attitudes towards wolves conducted between 1972 and 2002 in the US and Europe. The dependent variable was the percentage of respondents who expressed a positive attitude toward wolves or wolf

reintroduction. The study found the average positive attitude toward both wolves and their reintroduction was 53.1% of all respondents (std. dev. of 20.6% for n=108) (Williams 2002).

In an article by Kevin Schanning (2009), 16 studies from the Great Lakes Region (Michigan, Minnesota, and Wisconsin) conducted between 1974 and 2006 were analyzed to determine public attitudes towards gray wolf recovery and management. These studies' sample sizes ranged from 465 to over 4,100 respondents, and included landowners, farmers, endangered species license plates owners, and state residents. The majority of these surveys were conducted via mail-in survey (Schanning 2009). Majority support for wolf recovery programs was documented in all studies (Schanning 2009).

Support for management of wolves to minimize human-wolf conflict was examined in surveys between 1999 and 2004 (Schanning 2009). Schanning observed 46% of Michigan respondents and 41% of Wisconsin respondents supported a sport hunt of wolves in 2004, representing a near even split in respondents' attitudes with ~40% against the hunt (Schanning 2009). In a 2007 study, 68% of Wisconsin respondents supported a wolf harvest (Treves et al. 2007). Based on responses to survey questions, supportive attitudes towards lethal management of wolves can likely be attributed to concern about increased wolf-human conflict as wolf populations rise (Schanning 2009).

Factors Influencing Attitudes

Stakeholder identity and values play a huge role in shaping opinions about environmental issues (Schanning 2009). A study in Wisconsin assessed the public's tolerance of wolves and their acceptance of lethal control under five human-wolf conflict scenarios (Naughton-Treves 2003). The results indicate that deep-rooted social identity and occupation are more powerful

indicators of tolerance towards wolves than individual encounters with the species, stating "attitudes towards wolves are established early in life…and are connected to individual lifestyles and views of the place of humans in nature (Naughton-Treves 2003).

Political values also shape public attitudes towards wolves, as in the case of many rural citizens who feel that wolves are the symbol of unwelcome federal intervention (Naughton-Treves 2003). This negative attitude towards wolf reintroduction is attributed to the perceived unfair economic hardship incurred by loss of livestock (Naughton-Treves 2003). Compensation for livestock loss did not significantly impact tolerance of wolves (Naughton-Treves 2003). The study also found 42% of livestock producers favored lethal removal of depredating wolves (Naughton-Treves 2003).

Kovel & Mertig (2004) conducted a mail survey of Michigan residents regarding the use of lethal control in wildlife management. The results demonstrate support of lethal management of wildlife, but with limitations (Kovel & Mertig 2004). Opinions regarding lethal control vary across demographics; therefore managers need to consider public attitudes before creating policies in specific situations (Kovel & Mertig 2004). This is useful for wolf management as it reinforces the controversy around lethal control of recovering species.

Proximity to wolves and occupation can also influence attitudes towards wolves (Naughton-Treves 2003). The most hostile attitudes towards wolves and wolf recovery come from farmers and ranchers living near wolf populations or reintroduction sites (Naughton-Treves 2003). Williams also documented attitudes toward wolves and wolf reintroduction differed among social groups, indicating the individual's value system and self-identity are a factor in wolf management opinions (Williams 2002). This study also found a negative correlation

between positive attitudes toward wolf recovery and age, rural residence, and ranching and farming occupations; and a positive correlation with education and income (Williams 2002).

Limitations

Many organizations use public opinion surveys to determine public attitudes towards a specific issue at a specific point in time. Benefits of this data include being able to see statistically how the public feels about a certain issue, an extremely valuable measurement for controversial issues such as predator management (Dennis 1988).

However, there are limitations to public opinion polls. First, they only provide a snapshot of the respondents' opinions at a specific moment in time, and opinions may change as conditions change (Green 1997). In addition, surveys often do not capture the respondents' values or identity, which are often a better representation of their viewpoint on conservation issues (Green 1997). However, certain aspects of stakeholder values and identity can be inferred from these public opinion surveys, which are important aspects to acceptable policy formation.

Public Response to Wolf Hunting Seasons and Policies

Washington State is not the first state to have recovering wolf populations. A handful other states (MT, ID, WY, MI, WI) have seen rapid wolf recovery over the last five to ten years, and have achieved population numbers large enough to lead to removing state protections and classifying wolves as a game animal. However, data on the effects of these hunting seasons on wolf populations and wolf social structure does not yet exist. Media coverage surrounding these wolf hunts indicates they are controversial.

Radio-collared wolves from Yellowstone National Park (YNP) travelled outside the park's no-hunting zones and have been killed in Montana's hunting zones; wolf advocates were outraged that these "research wolves" could be hunted (Morell, accessed Dec. 11, 2012). In response, Montana and YNP worked with the game industry to develop regulations that would help prevent the taking of radio-collared wolves, including educating the public about the importance of radio-collared wolves and encouraging hunters to avoid shooting them (Morell, accessed Dec. 11, 2012). The creation of buffer zones around the park's high quality wolf habitat hopes to reduce the likelihood that Yellowstone wolves are killed (Associated Press, Dec. 20, 2012).

Minnesota has been criticized in the media for their lack of concern for public opinion when initiating a public hunt (Gibson, Jan. 31, 2013). A public opinion poll in Minnesota found that 80% of the public was against a wolf hunt but the state implemented one despite this opposition (Duluth News Tribune, Jan. 14, 2013). In September 2012, the Center for Biological Diversity and the group Howling for Wolves filed a lawsuit against Minnesota's Department of Natural Resources (DNR) on the grounds that they failed to provide ample opportunity for public comment (Duluth News Tribune, Jan. 14, 2013). Minnesota's 2001 wolf management plan requires that the species not be hunted or trapped for five years after removal from federal protections, which occurred in January 2012 (USFWS, Oct. 29, 2012).

Wyoming is facing similar lawsuits claiming wolves do not have enough protections; environmentalists believe the state's target numbers for wolves are too low. Michigan's public concern about wolf hunts stems from using the hunting season to manage wolf-human and wolf-livestock conflict. Many believe hunting is an unnecessary tool for protecting livestock now that farmers can shoot wolves on site that attack their herd. Michigan is considering a target hunt,

where the Michigan DNR will monitor the wolf population closely and adjust policies over time as needed (Michigan DNR, accessed Jan. 10, 2013).

Washington State and the WDFW can learn from these controversies, and design a hunting season that will both protect wolf population numbers and be acceptable to a polarized public.

Trapping Initiative and Hunting with Hounds

It is evident from the 1996 election that issues surrounding hunting and trapping wildlife are gaining mainstream attention (Minnis 1998). Washington State Initiative 713 (2000), making it a gross misdemeanor to capture an animal with certain body-gripping traps, passed with 54.6% to 45.4% in 2000 (ballotpedia.org, accessed Dec. 15, 2012). Public opinion in Colorado supported the banning of trapping wildlife as a cruel activity that further harmed endangered wildlife (Manfredo et al 1999).

Hunting predator species with hounds is also an issue for policy makers. The 2008 Washington State public attitudes survey questioned respondents about using dogs to hunt cougars and 46% opposed, and of those that opposed, 34% *strongly* opposed (Duda et al. 2008b). In April 2013, Wisconsin ruled the use of hounds while hunting wolves was legal during the regular season, inciting controversy from humane societies and wolf advocates (Richmond, Associated Press, accessed April 16, 2013).

Both advocates for dogs and for the target species feel using hounds to hunt predators is inhumane and harmful. Additionally, opponents argue that the use of hounds while hunting predators to violent interactions between the animals (Gibson, accessed Jan. 31, 2013).

Tribal Implications

When forming policy regulations for a gray wolf hunting season, the WDFW must consider the current attitudes of Native American Tribes in the area as wolves inhabit tribal lands and tribal governments are major stakeholders in this issue. Nationally, tribal attitudes have varied concerning management of recovering wolf populations, most importantly around lethal control by local governments and the implementation of hunting seasons.

In Michigan, tribes generally oppose a wolf hunting season on the grounds that wolves hold a culturally spiritual status (Williams, accessed Feb. 13, 2013). For many Indian tribes the wolf plays an important role in the creation stories, and is considered a brother or kin (Shelley 2011). Furthermore, Michigan tribes are concerned about the impacts of a hunt to pack structure, and how that would affect the sustainability of the current wolf population, as well as the absence of information about wise predator management (Williams, accessed Feb. 13, 2013). In Idaho, the Nez Perce Indian tribe has been heavily involved in management and monitoring of wolves, but currently has no hunting season (Walgamott, accessed Feb. 13, 2013). Other tribes in the Northwest have concerns about the impact recovering wolf packs will have on big game populations and the ability to provide meat for their families (Walgamott, accessed Feb. 13, 2013).

In the winter of 2012, the Colville Indian tribe in the Okanogan and Ferry counties of eastern Washington opened the first gray wolf hunting season in the state (Walgamott, accessed Feb. 13, 2013). The tribe divided their 2,100-square-mile reservation into seven wolf management zones, four of which are open to hunting (Figure 5). According to the chairman of the Colville Business Council, John Sirois, the tribe implemented the hunt to protect the supply of deer and elk, a crucial part of the tribe's meat supply (Mapes, accessed Feb. 13, 2013).

Conclusion

Public attitude surveys from Washington State and elsewhere indicate strong positive views towards wolf recovery and responsible wolf management. At the same time, a somewhat smaller majority supports a limited hunting season as a management tool. There is a positive correlation between positive attitudes towards wolf recovery and distance from recovery zones (Mech 1995). Generally, those with the most positive attitudes towards wolves are those with the least experience with recovering populations (Williams 2002).

Gray wolf recovery and management is an extremely sensitive issue among Washington State citizens. It is clear that policies surrounding this controversial species must be inclusive of as many stakeholder voices as possible in order to achieve the level of acceptance necessary for success.

Chapter Five: Implications of Findings

Public hunting of wolves in Washington State is controversial. Survey results from the WDFW study demonstrate that 50% of residents support hunting predators, and while 61% support some form of lethal control for wolves, that number drops to 46% in support of hunting wolves (Duda et al. 2008a). When planning a hunting season for wolves, the WDFW needs to consider the biological as well as social factors. Once gray wolves are removed from the protections of the Endangered Species Act, the use of human-dimensions research to understand under what conditions various stakeholders consider lethal management acceptable, and to evaluate the acceptability of agency efforts to increase public tolerance for wolves is crucial when forming gray wolf policy (Way 2012).

Indiscriminate hunting can lead to reduced ability to maintain territory, increased survival pressure/decreased breeding by remaining members, decreased pup survival/higher natural mortality rates, and decreased generational learning (Rutledge 2010). These potential impacts can result in increased depredation on livestock and decreased wolf population numbers, potentially resulting in relisting the species under state protections. Responsible wolf control protects rural interests while promoting public tolerance and protection for wolves (Niemeyer 1994). Policy makers must consider biology and public sensitivities to create policies that maximize recreational value of wolf harvesting, minimize public animosity towards it, and meet harvest objectives (Mech 2010).

A public hunting season will be a controversial management tool, and therefore hunting policy must be based on science and stakeholder attitudes to be successful. Given Washington's limited connectivity between high quality habitat in northeast and southeast Washington and the

Cascade and Olympic Mountains, and given aggressive wolf management in British Columbia to the north, indiscriminate hunting could potentially lead to difficulty in maintaining a self-sustaining persistent wolf population (Smith 2010).

WDFW has outlined public acceptance and understanding of wolf conservation and management needs, as well as responsibly managing wolf-livestock conflict as two goals for wolf recovery (Wiles 2011). Based on the survey data from 2008, and complimentary survey data from Williams (2002) and Schanning (2009), it is clear that the general public both supports wolf recovery and a limited hunt. It is crucial that these policies responsibly manage wolf populations to avoid public backlash and promote co-existence.

Washington State has identified maintaining healthy ungulate populations that provide abundant prey for wolves and other predators, as well as harvest opportunities for hunters as a goal for wolf recovery (Wiles 2011). Wolf populations account for minor declines in ungulate populations, those declines can be attributed to a number of factors and are not significant enough to impact harvest levels for hunters (Bangs 2005, Smith et al. 2011).

The literature reveals that general public attitudes toward predator recovery are influenced by personal experience, attitudes in the media, proximity to recovering populations, and availability of accurate information. This suggests that in order to positively impact public attitudes and promote co-existence with wolves, the WDFW policies need to focus on education and outreach targeted at landowners and the general public over lethal management.

Chapter Six: Incorporating Findings to Inform Policy

The Limitations of Science

Environmental policy involves science, ethics, and stakeholder values (Alario 2001). The limitations of relying solely on the best available science are in the policymaking, and in the transparency and accountability of the policy makers (Carolan 2008). This can seem undemocratic to the public, and reduce the legitimacy of the policies.

While "environmental law fundamentally depends on… environmental science," that science is uncertain, therefore creating policies that are uncertain (Biber 2012). Policies that rely too heavily on this uncertain science allow for "the concealment of value choices and trade-offs" by interest groups, politicians, and agencies (Biber 2012). This creates a need to include other factors in policy making, even if the science provides answers to a specific question (Sarewitz 2004).

Scientific findings used in policy making present issues for policy makers, as this science impacts practical interests (Alario 2001). This supports the idea that more attention be placed on decisions made between people, not scientific theories (Alario 2001). In addition, deliberation and negotiation are just as important in environmental policy making as the scientific proof (Alario 2001). Successful policies incorporate negotiation and science, and therefore science alone does not complete the policy making puzzle (Sarewitz 2004).

The Need for Many Voices

"Environmental policy depends for its success on public participation" (Eden 1996). There is a need include as many stakeholders as possible, and to understand not only what is at

stake for each stakeholder, but also how to make the policies acceptable to as many stakeholders as possible, otherwise these policies run the risk of failing (Altman 1994).

Regulatory discontent about past environmental policy has led to newer approaches in environmental management that can achieve both improved policy performance and long-term ecological sustainability (Cortner 2000). These new approaches emphasize the importance of not only science, but also public involvement that reflects changing societal goals, collaborative decision-making, and adaptable institutions (Cortner 2000).

Gray wolf recovery and management is a polarizing issue among the public, and includes a large variety of stakeholders. Public participation in conjunction with scientific expertise can help create a well-rounded, widely accepted environmental policy (Biber and Brosi 2010).

Incorporating Values, Identity, and Science

In order to create and successfully implement environmental policy, it is important to consider the varying ways in which people relate to their environment and nature; to understand the different ways they experience their environment through culture and social interaction (Eden 1996). Once these methods have been identified, it is important to build them into environmental management so the policies can be sustainable, acceptable and enforceable (Eden 1996).

One of the ways to incorporate both scientific expertise and stakeholder values outside the scientific realm are “boundary organizations” (Carolan 2006). While there is little research done on these facilitators of science and non-science experts, they play an important role in facilitating collaboration among stakeholders (Carolan 2006). A deliberative democratic turn in wildlife management would focus on understanding the networks of discussions and debate on the issue, and less on the specific decision-making process (Parkins 2005).

Chapter Seven: Policy Recommendations

The Washington Department of Fish and Wildlife (WDFW) defines a *pack* as two animals traveling together, and a *breeding pair* as the alpha pair, their adult and young offspring, and other adult-aged members (Wiles 2011). In general, it is recommended that the WDFW use a precautionary approach to forming hunting policy, which will help account for uncertainty in the science, offer a wider range of alternatives to potentially harmful actions, and increase public participation in the policy making process (Kriebel 2001). The following recommendations support both this approach to policy and the outlined objectives for wolf recovery in the Gray Wolf Management Plan:

Recommendation One: Inclusion of a scientific panel
Recommendation Two: Designated hunting zones; buffer zones
Recommendation Three: Responsible restrictions on hunting season
Recommendation Four: Managing above minimum target recovery levels
Recommendation Five: Agency resources favor non-lethal preventative measures
Recommendation Six: Wolf hunting policy formation should be a collaborative effort

Recommendation One: Inclusion of Scientific Panel

The success of wildlife management policy is dependent on that policy being based on scientific information (Callon 2001). Because science brings uncertainties to the policy arena, it is important that in rapidly changing times "we must redouble our efforts to inform, explain and communicate" (Callon 2001). The inclusion of a scientific panel when forming and implementing gray wolf hunting policy will help ensure the short and long term goals of the WDFW are met and add legitimacy to the policy outcomes (Callon 2001). A scientific panel will have the knowledge and experience to inform policy that supports the WDFW objectives for gray wolf recovery, and can monitor the impacts of hunting on the social structure and

population of the species to adjust policies as needed. Given all the uncertainties, a scientific panel will help define the parameters of a precautionary policy necessary to account for the uncertainty of science (Jasanoff 1987).

A scientific panel will also bring legitimacy to the policy making process for gray wolf hunting, giving the public confidence in Washington State's determination to recover the species and manage wolves responsibly (Jasanoff 1990). Public criticism of current gray wolf hunting in neighboring states concerns the failure to use scientific data in forming policies, as well as a lack of confidence in the state's willingness and motivation to keep wolf populations at a sustainable level. As there is low public support for hunting predators in WA, a program to hunt predators will need to be justified by science (Duda et al. 2008). A scientific panel will offer legitimacy and a sense of confidence that the WDFW will protect wolf populations at sustainable levels (Jasanoff 1987).

The creation of a scientific panel will also serve as the entity for public education about wolf biology and recovery (Bangs 2005). This panel should work with government and conservation organizations state and nationwide to provide the public with knowledge about wolf biology and conservation. The WDFW identified public education about coexisting with wolves and increasing public tolerance as two objectives for wolf management (Wiles 2008). The more informed the public is about conservation issues, the more supportive they are of recovery efforts and management policies (Bangs 2005). A scientific panel directly supports those objectives. In short, a more educated public is more likely to support a limited wolf hunt with well-rounded policies addressing all issues and stakeholders (Bangs 2005).

Recommendation Two: Designated Hunting Zones and Buffer Zones

Using designated zones when hunting predators can be an efficient way of managing the population in a sustainable way, as well as managing conflict. A zonal approach to wolf management supports the species inhabiting areas where native ungulate prey is more abundant and interactions with humans are low (Mech 1995). With this approach, policy makers would designate specific zones for potential high-value wolf habitat while distinguishing them from other zones where habitat value is lower and wolf-human conflict is more likely (Mech 1995). The use of zones supports the precautionary approach, as they help ensure high quality habitat remains intact and wolves have safe-haven areas to birth and rear young (Mech 1995).

Zoning can be used to manage human-wolf conflict by promoting a limited public hunt in areas of high wolf-livestock conflict, and restricting the hunt in areas of high habitat value where functioning wolf packs are more likely to be raising pups (Mech 1995). Though the potential for harvesting wolves to lead to *increased* depredation on livestock exists, and permitting a limited hunt in areas of likely wolf-livestock conflict may seem counterproductive with the potential to worsen conflict, it is anticipated that a responsible, limited hunt in those areas can help manage conflict without the adverse effect of increasing depredations (Mech 1995). Close monitoring of the impacts of the public hunt will be important to ensure continued success of the species (Mech 1995).

Designating specific zones as "no-wolf-hunting" will not likely lead to a dramatic increase in wolf population numbers in those zones (Thurber 1993). Likewise, although these zones would potentially have higher wolf densities than zones with a limited hunt, the ungulate populations in these zones would not decline to levels detrimental to hunters (Garrot et al 2005). Populations in northeast Washington will most likely not increase much, even if hunting is

limited in that area; instead new packs would most likely be suppressed south towards Spokane by the current wolf population, and as this is a highly developed area with more agricultural land, a more robust hunting zone would be designated there to account for conflict (J. Minbashian, personal communication, May 15, 2013).

In Washington State, zonal wolf management would consist of legal public hunting in areas of high conflict and low habitat value. Areas that are more developed and/or dominated by ranching or agriculture would act as wolf-free zones where a limited hunt is permitted to help regulate the population and manage such conflict (Mech 2010). More specifically, the far eastern side of the state and directly west of the Cascade Mountains are areas where high conflict is occurring or anticipated as populations recover, and these areas would contain a limited hunt. Conversely, public or private forestry land in northeast, north central and southeast Washington State are excellent wolf habitat zones with established packs and would be considered no-hunting zones (Bangs 2005). In these areas, wolves are more likely to den and rear pups, the potential for livestock conflict is decreased, and natural prey is more abundant. A zonal approach could help eliminate the need for costly deliberate control of wolves while raising public acceptance (Mech 2010).

Buffer zones around higher quality habitat are also a management tool useful in achieving the objectives of the WDFW (Mech 1994). With certain areas in the state designated as “no hunting zones”, creating buffer zones around those areas with a more limited hunting season or tighter restrictions will aid wolf population sustainability as well as demonstrate to the public that the WDFW is determined to recover the species to sustainable population levels and maintain those levels (Mech 1994). By limiting the already limited hunting season in these buffer zones, wolves are more likely to persist in the high quality habitat areas.

Due to the long distances wolves can travel to find den or rendezvous sites, or hunt for food, the size of these buffer zones should be based on the best possible science. Creating areas around high quality habitat where hunting is more limited will help reduce the impacts to pack structure, and is a more acceptable approach to the public (White 1996). It is likely that wolves killed in buffer zones will be lone or dispersing wolves, and therefore the negative impacts to pack structure would be less likely than in areas with higher wolf densities (White 1996).

Recommendation Three: Responsible Regulations on Season

To be publically acceptable, a wolf-hunting season must be responsibly regulated with conservative bag limits and season dates (Duda et al. 2008, Williams 2002). Responsible regulations are a precautionary measure to help account for the uncertainty about the impacts of hunting on wolf packs, and how the public will react. These regulations would be a part of an adaptive management and monitoring plan that opens the door for adjusting regulations if preliminary data suggests wolves are being overharvested.

Conservative Dates

Opening the public hunting season after pups have reached adult size, in late November, can reduce public outrage about killing small pups (Mech 2010). In addition, wolves have left rendezvous sites by this time, removing the fear that one hunter can find an entire pack and inform other hunters (Mech 2010). Ending the season before most alpha wolves mate in February will reduce the likelihood of a pregnant female being killed, helping to reduce public outrage and negatively impact the breeding season (Mech 2010). Therefore, the recommended hunting season is from November to January 31. Not only will these regulations help manage

public opinion about hunting small pups or pregnant alphas, a shorter season reduces the likelihood of over-exploitation, potentially resulting in population decline (Mech 2010).

Bag Limits

The inclusion of bag limits will help ensure populations do not fall below target recovery levels. Bag limits are a limit on the total number of taken individuals permitted, and this should operate on the most current and reliable science available. Many states with wolf hunting seasons currently have bag limits, and these are a widely accepted hunting restriction. The recommended number of bag limits per person is one. This allows the hunter to have his/her trophy without the potential death of many individuals in a pack (Mech 2010).

Prohibit Hunting Radio-Collared Wolves

It is recommended that a public hunting season ban hunting radio-collared wolves. Radio-collared wolves are typically alpha pack members, and provide researchers with invaluable data, including mating habits, dispersal distances and times, and predator-prey relationship information (Ballard 1987). Figure 6 highlights the known dispersal of radio-collared wolves from 1995-2008 (Figure 6). Other states have experienced public backlash about collared wolves being killed during public hunting seasons, such as research wolf 832F from Yellowstone National Park, a six-year-old alpha female and the last of three radio-collared wolves in YNP (Morell, Science Insider, accessed Dec. 11, 2012). The loss of 832F and other radio-collared wolves raised concern in December 2012; banning hunting these important wolves in Washington will not only help prevent public outrage, but also preserve the scientific integrity of wolf management.

Prohibit Trapping and Hunting with Hounds

It is recommended that the WDFW ban the use of hounds when hunting wolves and enforce the ban on body-gripping traps. Initiative 713 passed with majority support, and neighboring states have seen backlash from wildlife conservation organizations and the general public on the use of traps, as they are often seen as inhumane and cruel. Hunting with hounds has been criticized as inhumane for both wolves and the hounds. To avoid dissent regarding these two aspects of hunting, it is recommended that the WDFW remove them both from the hunting policy conversation.

Recommendation Four: Manage Population above Minimum Recovery Goals

Because of the scientific uncertainty about wolf population biology and the effects of harvest on wolf populations, it is recommended that the Washington State gray wolf population be managed above the minimum set recovery goal population numbers to avoid dropping below target levels potentially resulting in relisting under state protections (Shaffer 1981). To manage wolves at minimum recovery requirements leaves little room for unforeseen environmental or human factors that can negatively impact wolf packs. Harsh weather, illegal killing, disease, or a poor reproductive season could all result in a decrease in population numbers; if wolves have been hunted to minimum recovery levels, this decrease could drastically reduce population growth and inhibit recovery (Shaffer 1981). Recovering wolf populations in Montana and the Northern Rocky Mountains, though bordering on recovery population goals, were still susceptible to environmental changes; management of these populations must consider this fact when forming policies (Boyd 1999).

The WDFW should manage the wolf population above 15 breeding pairs. While the Management Plan states that 15 breeding pairs is an adequate recovery objective for delisting from state protections, the plan also states that "under scenarios that capped the population at 15 breeding pairs, there was a 93% probability that the wolf population would fall below the listing goal" over a 50 year time span, even when accounting for immigration (Wiles 2011). This suggests that when forming wolf-hunting policy, the WDFW must manage wolves above this target level to account for unforeseen factors that could threaten the population. The WDFW's objective to recover and maintain a sustainable wolf population for greater than 50-100 years requires them to follow the gray wolf management plan finalized in 2011, and manage wolves above minimum recovery goals.

Recommendation Five: Agency Resources Favor Non-Lethal Preventative Measures

In areas with high potential for increased wolf-human conflict, employing preventative measures to protect livestock and pets can help create a successful relationship between wolves and humans, which improve the prospects for management (Way 2012). WDFW should favor non-lethal preventative measures, especially when attempting to manage livestock predation (Bradley 2005). A public hunting season alone is not a population management tool, and has limited effectiveness in managing wolf-livestock conflict (Breck 2004). The use of preventative measures such as fladry lines, range riders, and various livestock management techniques will reduce wolf-livestock conflict and is a more effective use of agency resources (Musiani 2003). Promoting the use of proactive measures can help encourage a more positive relationship between wolves and humans in areas of higher wolf densities (Lance 2009).

The May 2013 signing of SB 5193, effective July 28, 2013, allocates resources and funding to these preventative measures, and helps ensure management agencies will focus efforts on preventing conflict rather than managing it after-the-fact (Washington State Legislature 2013). Supporting non-lethal preventative measures supports the precautionary approach to policy, as well as promotes public tolerance and understanding of wolf recovery and conservation needs.

Fladry Lines

The use of fladry lines, brightly colored flags hanging from ropes that act as a barrier to predators, successfully prevented wolves from depredating on cattle on 23 occasions over two 60-day tests on three cattle pastures (Musiani 2003). Wolves approached the barriers, but did not cross. Wolves did depredate on cattle on neighboring ranches during the trials. However, fladry lines could offer a cost-effective tool to manage livestock conflict, and help prevent the need to lethally manage wolves (Musiani 2003).

Range Rider Program

Though this program is in its infancy in eastern Washington State, preliminary success has demonstrated that human presence while cattle are grazing deters wolves from the area and helps prevent depredation on livestock. Ranger riders ride on public and private lands during grazing season, looking for signs of wolves and hazing wolves that approach cattle (Nesbitt, accessed May 30, 2013). While this program is more costly than fladry lines, the benefits to ranchers can outweigh the costs (Oregonwild.com, accessed May 30, 2013).

Livestock Management Techniques

Educating landowners about preventative measures like putting livestock out to pasture later in the season and removing livestock carcasses immediately after a loss to deter scavenging will reduce wolf depredation on livestock. Putting cattle out to pasture later in the season prevents small, vulnerable calves from being in the area with little protection (Musiani 2003). Instead, calves will be larger and older, and therefore less appealing prey for wolves, who generally hunt weak or small ungulates (Musiani 2003).

Once wolves have depredated on livestock consistently without a change in response actions by management agencies or landowners, the probability for those wolves to become conditioned on livestock as their primary food source increases drastically (Morehouse 2011). Once this conditioning occurs, even lethal removal of members of the pack often will not deter depredation, as in the case of the Wedge Pack in eastern Washington. Wolves depredate on livestock more during the grazing season, and removal of cattle carcasses and other preventative measures, especially during this time, will aid in reducing wolf-livestock conflict (Morehouse 2011).

Recommendation Six: Hunting Policy Formation is a Collaborative Process

For top predator management policy to be effective it must be collaborative among all stakeholders involved (Gregory 2001). For Washington State, this includes WDFW, USFWS, local tribes, conservation organizations, the game industry, the agriculture and ranching industries, and the public. To avoid backlash from stakeholders, the WDFW must make every effort to include as many voices as possible in the process (Kriebel 2001). The precautionary

approach to policy helps ensure that public participation and stakeholder involvement is a keystone in the policy-making process (Kriebel 2001).

Neighboring states have received criticism for their hunting policies with regards to lacking of public input. Collaboration and communication among all stakeholders will help ensure hunting policy is scientifically sound, while also helping reduce conflict (Kriebel 2001). It would be beneficial to conduct a public opinion survey as a follow-up to the 2008 poll focused on wolf management, and specifically the use of a zonal approach to wolf hunting that is collaboratively developed and balances biological and social needs. This survey will offer an updated view of public opinions and will help to inform potential future gray wolf hunting policies.

Responsible wolf control protects rural interests while promoting public tolerance and protection for wolves (Niemeyer 1994). As government agencies become more experienced in dealing with wolf-human conflict, conversations between ranchers and wolf advocates are likely to become less polarized, and controlling of wolves becomes more efficient (Niemeyer 1994).

Chapter Eight: Discussion and Conclusions

It is critical for the Washington Department of Fish and Wildlife to create and implement scientifically based, flexible and politically acceptable policies when forming a public gray wolf hunting season. Recovering top-predator management requires the use of both science and stakeholder participation to create policy that incorporates both the biological needs of the species and the concerns of stakeholders (Bittner 2009).

Very little is known about the impacts of hunting and lethal management on wolf pack structure, and even less is known about the impacts to wolf populations or population recovery. It is this uncertainty that requires a precautionary approach to policy, and creates a variety of future research necessary for successful policy (Biber 2012).

To support the objectives outlined in the 2011 Gray Wolf Management Plan, I recommend the following for gray wolf hunting policy:

Recommendation One: Inclusion of a scientific panel
Recommendation Two: Designated hunting zones; buffer zones
Recommendation Three: Responsible restrictions
Recommendation Four: Manage above minimum target recovery levels
Recommendation Five: Agency resources favor non-lethal preventative measures
Recommendation Six: Wolf hunting policy formation is a collaborative effort

In addition to the impacts on wolf social structure and population viability overall, it is imperative that further research be conducted on the effectiveness of predation preventative over time. Research on the effects of compensation for wolf-killed livestock on public attitudes is also necessary to discern if compensation is a useful management tool (Thompson 1993). The potential for wolves to be an economic asset for the tourist industry should be examined more closely as well, as surveys found that people will travel to see or hear wolves in the wild. This subject will be more important as populations increase, and could impact hunting regulations to

ensure overharvesting does not occur to economic detriment. Finally, research on the impacts to the genetic diversity of wolf populations of harvesting will be important in determining the long-term consequences of hunting (Jedrzejewski 2005).

As of May 2013, the USFWS is considering removing federal protections for wolves completely throughout the lower 48 states. This would place all wolves in Washington State under the management of the WDFW. If this change occurs, policies and management objectives would need to be re-examined on a statewide scale and adjusted accordingly to ensure wolves statewide were managed responsibly.

Wolves in Washington State are recovering quickly, and it is widely accepted that population numbers will reach recovery goals in the very near future. This will change the status of wolves from state protected to a game species. It is crucial that before this happens, policies are in place that will both reflect biologically sound recovery goals, as well as be acceptable to the majority of the public.

Works Referenced

Alario, Margarita and Brun, Michael (2001). Uncertainty and Controversy in the Science and Ethics of Environmental Policy Making. *Theory and Science*, 2(1).

Altman, J. A. and Petkus, E. Jr. 1994. Toward a stakeholder-based policy process: An application of the social marketing perspective to environmental policy development. *Policy Sciences,* 27(1): 37-51.

Associated Press article. "Conservation group wants wolf buffer zone around Yellowstone Park". (Accessed December 11, 2012). http://missoulian.com/news/state-and-regional/conservation-group-wants-wolf-buffer-zone-around-yellowstone-park/article_f3abef98-4aa9-11e2-901b-001a4bcf887a.html

Ausband, D. E., Mitchell M. & Bassing, S. 2012, October. 2012 Progress report of a study on The effects of mortality on gray wolves in the Rocky Mountains. University of Montana. Montana Cooperative Wildlife Research Unit: Wolf Project, 1-11.

Ballard W. B. 1987, July. Ecology of an Exploited Wolf Population in South-Central Alaska. *Wildlife Monographs, 98*: 3-54.

Bangs, E. E. 2005, Aug. Managing wolf-human conflict in the northwestern United States. In Woodroffe, R., Thirsgood, S, & Rabinowitz, A. (Eds.), *People and Wildlife, Conflict or Co-existance?* (pp 340-356). The Zoological Society of London, London: Cambridge University Press.

Becker, S.A., P.F. Frame, D. Martorello, and E. Krausz. 2013. Washington Gray Wolf Conservation and Management 2012 Annual Report. Pages WA-1 to WA-16 in U.S. Fish and Wildlife Service Rocky Mountain Wolf Program 2012 Annual Report. USFWS, Ecological Services, 585 Shepard Way, Helena, Montana, 59601.

Berger, K. M. and Gese, E. M. 2007, Nov. Does interference competition with wolves limit the distribution and abundance of coyotes? *Journal of Animal Ecology,* 76(6): 1075-1085.

Biber, E. and Brosi, B. 2010. Officious Intermeddlers of Citizen Experts: Petitions and Public Production of Information in Environmental Law. UCLA Law Review, 321-400. http://heinonline.org/HOL/Page?handle=hein.journals/uclalr58&div=11&g_sent=1&collection=journals

Biber, E. 2012. Which Science? Whose Science? How Scientific Disciplines Can Shape Environmental Law. *The University of Chicago Law Review,* 79(2): 471-552.

Bijker, W., Bal, R., & Hendriks, R. 2009. The Paradox of Scientific Authority: The Role of Scientific Advice in Democracies. The MIT Press, London.

Bittner V. 2009. Wolves in the Crosshairs: A Scientific Case against the Final Rule of the U.S. Fish and Wildlife Service Removing Northern Rocky Mountain Gray Wolves from the Endangered Species List. *Hastings West-Northwest Journal of Environmental Law and Policy,* 15(2): 281-324.

Boyd D. K. & Pletscher, D. H. 1999, Oct. Characteristics of Dispersal in a Colonizing Wolf Population in the Central Rocky Mountains. *The Journal of Wildlife Management,* 63(4): 1094-1108.

Bradley E. H., Pletscher, D. H., Bangs, E. E., Kunkel, K. E., Smith, D. W., Mack, C. M., Meier, T. J., Fontaine, J. A., Niemeyer, C. C., & Jimenez, M. D. 2005, Oct. Evaluating Wolf Translocation as a Nonlethal Method to Reduce Livestock Conflicts in the Northwestern United States. *Conservation Biology,* 19(5): 1498-1508.

Brainerd S. M. 2008. Effects of Breeder Loss on Wolves. *Journal of Wildlife Management,* 72(1): 89-98.

Brainerd S. M. et al. 2003. The effects of alpha wolf loss on reproductive success and pack dynamics. *Norwegian Institute for Nature Research (NINA),* The World Wolf Congress 2003 – Bridging Science and Community, Banff, Canada, (accessed February 20, 2013).

Breck, S. & Meier, T. 2004. Managing Wolf Depredation in the United States: Past, Present, and Future. *Wildlife Research Center – Staff Publications*. Paper 83.

Callon, M., Lascoumes, P., and Barthe, Y. 2001. Acting in an Uncertain World: An Essay on Technical Democracies. Massachusetts Institute of Technology.

Carolan, M. S. 2006. Science, Expertise, and the Democratization of the Decision-Making Process. *Society & Natural Resources: An International Journal,* 19(7): 661-668.

Carolan, M. S. 2008. Is it a Distinct Subspecies? Preble's Mouse and the "Best Available Science" Mandate of the Endangered Species Act. *Society & Natural Resources: An International Journal,* 21(10): 944-951.

Carolan, M. S. 2008. The politics in environmental science: The Endangered Species Act and the Preble's mouse controversy. *Environmental Politics,* 17(3): 449-465.

Collingridge, D., Reeve, C. 1986. Science Speaks to Power: The Role of Experts in Policy. St. Martin's Press, New York.

Conover, M. R. 2001, Sept. Effect of Hunting and Trapping on Wildlife Damage. *Wildlife Society Bulletin,* 29(2): 521-532.

Cortner, H. J. 2000. Making science relevant to environmental policy. *Environmental Science and Policy,* 3(1): 21-30.

Creel, S., & Rotella J. J. 2010. Meta-Analysis of Relationships between Human Off-take, Total Mortality and Population Dynamics for Grey Wolves (Canis lupus). *PLoS ONE,* 5(9).

Darimont, C. T., Reimchen T. E., and Paquet P. C. 2003, Feb. Foraging behaviour by gray wolves on salmon streams in coastal British Columbia. *Canadian Journal of Zoology*, 81(2): 349-353.

Dennis, S. 1988. Incorporating public opinion surveys in national forest land and resource planning. *Society and Natural Resources: An International Journal,* 1(1): 309-316.

Dietsch, A. M., T. L. Teel, M. J. Manfredo, S. A. Jonker, and S. Pozzanghera. 2011. State report for Washington from the research project entitled "Understanding People in Places." Project Report for the Washington Department of Fish and Wildlife. Department of Human Dimensions of Natural Resources, Colorado State University, Fort Collins, Colorado.

Duda, M. D., T. Beppler, S. J. Bissell, A. Criscione, B. Hepler, J. B. Herrick, M. Jones, A. Ritchie, C. L. Schilli, T. Winegord, and A. Lanier. 2008a. Public opinion on hunting and wildlife management in Washington. Responsive Management, Harrisonburg, Virginia.

Duda, M. D., T. Beppler, S. J. Bissell, A. Criscione, B. Hepler, J. B. Herrick, M. Jones, A. Ritchie, C. L. Schilli, T. Winegord, and A. Lanier. 2008b. Hunters' opinions on wildlife management and other hunting issues in Washington. Responsive Management, Harrisonburg, Virginia.

Eden, S. 1996. Public participation in environmental policy: considering scientific, counter-scientific and non-scientific contribution. *Public Understanding of Science,* 5(3): 183-204.

Fischer, Frank. 2000. Citizens, Experts, and the Environment: The Politics of Local Knowledge. Duke University Press.

Garrott, R. A., Justin A. Gude, Eric J. Bergman, Claire Gower, P.J. White, and Kenneth L. Hamlin. 2005. Generalizing Wolf Effects across the Greater Yellowstone Area: A Cautionary Note. *Wildlife Society Bulletin,* 33(4): 1245-255.

Gehring, T. M. & Potter, B. A. 2005. Wolf habitat analysis in Michigan: an example of the need for proactive land management for carnivore species. *Wildlife Society Bulletin*, 33(4): 1237-1244.

Governors Office of Indian Affairs, Access Washington: Official State Government Website. http://www.goia.wa.gov/tribal-information/map.htm (accessed April 17, 2013).

Green, D., Askins, G. R., and West, P. D. 1997. Public opinion: obstacle or aid to sound deer management? *Wildlife Society Bulletin*, 25(2): 367-370.

Gregory, R. and Wellman, K. 2001. Bringing stakeholder values into environmental policy choices: a community-based estuary case study. *Ecological Economics*, 39(1): 37-52.

Gude, J. A. et al. 2012. Wolf population dynamics in the U.S. Northern Rocky Mountains are affected by recruitment and human-caused mortality. *The Journal of Wildlife Management*, 76(1): 108-118.

Haber, G. C. 1996. Biological, Conservation, and Ethical Implications of Exploiting and Controlling Wolves. *Conservation Biology*, 10(4): 1068-1081.

Halofsky, J.S., W.J. Ripple and R.L. Bestcha. 2008. Recoupling fire and aspen recruitment after wolf reintroduction in Yellowstone National Park, USA. *Forest ecology and management,* 256(5): 1004-1008.

Hamlin, K. L. and J. A. Cunningham. 2009. Monitoring and Assessment of Wolf- Ungulate Interactions and Population Trends within the Greater Yellowstone Area, southwestern Montana, and Montana statewide: Final Report. Montana Department of Fish, Wildlife, and Parks, Wildlife Division, Helena, Montana, USA.

Harrington F. H. and Mech D. L. 1979. Wolf Howling and Its Role in Territory Maintenance. *Behaviour*, 68(3/4): 207-249.

Harrington F. H., Mech D. L., and Fritts S. H. 1983. Pack Size and Wolf Pup Survival: Their Relationship under Varying Ecological Conditions. *Behavioral Ecology and Sociobiology*, 13(1): 19-26.

Holmes, J. and Clark, R. 2008. Enhancing the Use of Science in environmental policy-making and regulation. *Environmental Science and Policy*, 11(8): 702-711.

Idaho Department of Fish and Game and Nez Perce Tribe. 2013. 2012 Idaho wolf monitoring progress report. Idaho Department of Fish and Game, 600 South Walnut, Boise, Idaho; Nez Perce Tribe Wolf Recovery Project, P.O. Box 365, Lapwai, Idaho. 72 pp.

Jasanoff S. S. 1987. Contested Boundaries in Policy-Relevant Science. *Social Studies of Science*, 17(2): 195-230.

Jasanoff, S., 1990. The Fifth Branch: Science Advisors as Policymakers. Harvard University Press, Cambridge, MA.

Jedrzejewski, W. et al 2005. Genetic diversity and relatedness within packs in an intensely hunted population of wolves *Canis lupus*. *Acta Theriologica*, 50(1): 3-22.

Kovel, M. H. & Mertig, A. G. 2004. Attitudes of the Michigan public and wildlife agency personnel toward lethal wildlife management. *Wildlife Society Bulletin*, 32(1): 232-243.

Kriebel, D. et al. 2001. The precautionary principle in environmental science. *Environmental Health Perspectives*, 109(9): 871-876.

Lance, N. J. 2009. "Application of Electrified Fladry to Decrease Risk of Livestock Depredations by Wolves (Canis lupus)". *All Graduate Theses and Dissertations*. Paper 282.

Licht D. S. et al. 2010. Using Small Populations of Wolves for Ecosystem Restoration and Stewardship. *BioScience*, 60(2): 147-153.

Manfredo, M. J., Pierce, C. L., Fulton, D., Pate, J., & Gill, B. R. 1999. Public Acceptance of Wildlife Trapping in Colorado. *Wildlife Society Bulletin*, 27(2): 499-508.

Manfredo, M. J., Teel, T. L., & Bright, A. D. 2003. Why Are Public Values Toward Wildlife Changing? *Human Dimensions of Wildlife*, 8: 287-306.

Mapes, Lynda. "Colville tribe hunting wolves to protect deer, elk, chairman says." *The Seattle Times*, December 7, 2012, (accessed February 13, 2013). http://seattletimes.com/html/fieldnotes/2019857675_colville_tribe_hunting_wolves_to_protect_deer_elk_chairman_says.html

Mech, D. L. 1994. Buffer Zones of Territories of Gray Wolves as Regions of Intraspecific Strife. *Journal of Mammalogy*, 75(1): 199-202.

Mech, D. L. 1995, Apr. The Challenge and Opportunity of Recovering Wolf Populations. *Conservation Biology*, 9(2): 270-278.

Mech, D. L. 2001. Managing Minnesota's Recovered Wolves. *Wildlife Society Bulletin*, 29(1): 70-77.

Mech L.D., D.W. Smith, K. M. Murphy, and D. R. MacNulty. 2001. Winter severity and wolf predation on a formerly wolf- free elk herd. *Journal of Wildlife Management,* 65: 998-1003.

Mech, D. L. & Boitani, L. 2003. *Wolves: Behaviour, Ecology and Conservation*. University of Chicago Press, 1-2.

Mech, D. L. 2010. Considerations for Developing Wolf Harvesting Regulations in the Contiguous United States. *Journal of Wildlife Management*, 74(7): 1421-1424.

Meriggi, A. and Lovari, S. 1996, Dec. A Review of Wolf Predation in Southern Europe: Does the Wolf Prefer Wild Prey to Livestock? *Journal of Applied Ecology*, 33(6): 1561-1571.

Michigan Department of Natural Resources, (accessed February 20, 2013). http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_12205-32569--,00.html

Montana Fish, Wildlife and Parks, (accessed February 21, 2013). http://fwp.mt.gov/hunting/regulations/

Morell, Virginia. (2012). "Hunters kill another radio-collared Yellowstone National Park wolf". Science Insider, (accessed December 11, 2012). http://news.sciencemag.org/scienceinsider/2012/12/hunters-kill-another-radio-colla.html

Morehouse, A. T. and Boyce M. S. 2011. From venison to beef: seasonal changes in wolf diet composition in a livestock grazing landscape. *Frontiers in Ecology and the Environment,* 9(8): 440–445.

Musiani, M. et al. 2003. Wolf Depredation Trends and the Use of Fladry Barriers to Protect Livestock in Western North America. *Conservation Biology*, 17(6): 1538-1547.

Naughton-Treves, L., Grossberg R., & Treves A. 2003. Paying for Tolerance: Rural Citizens' Attitudes toward Wolf Depredation and Compensation. *Conservation Biology*, 17(6): 1500-1511.

Nesbitt, K. 2010, July. "Range rider program implemented to help reduce livestock losses to wolves." Oregon Wild, (accessed May 30, 2013). http://www.oregonwild.org/about/press-room/press-clips/range-rider-program-implemented-to-help-reduce-livestock-losses-to-wolves

Nesbitt, K. 2010, August. "Riding the range in wolf country." The Observer, (accessed May 30, 2013). http://www.lagrandeobserver.com/News/Local-News/Riding-the-range-in-wolf-country

Nie, M. A. 2001. The Sociopolitical Dimensions of Wolf Management and Restoration in the United States. *Human Ecology Review*, 8(1).

Nie, M. A. 2002. Wolf Recovery and Management as Value-based Political Conflict. *Ethics, Place & Environment: A Journal of Philosophy and Geography*, 5(1): 65-71.

Niemeyer, C. C., Bangs E. E., Fritts S. H., Fontaine J. A., & Jimenez M. D. 1994. "Wolf Depredation Management in Relation to Wolf Recovery." *Proceedings of the Sixteenth Vertebrate Pest Conference*, Paper 41.

Parkins, J. R. & Mitchell, R. E. 2005. Public Participation as Public Debate: A Deliberative Turn in Natural Resource Management. *Society and Natural Resources*, 18(6): 529-540.

Person, D. K., & Russell A. L. 2008. Correlates of Mortality in an Exploited Wolf Population. *Journal of Wildlife Management*, 72(7): 1540-1549.

Pitt, W. C., Box P. W., & Knowlton F. F. 2003. An Individual-Based Model of Canid populations: modeling territoriality and social structure. *Ecological Modelling*, 166: 109-121.

Pouyat, R. V. 1999. Science and Environmental Policy: Making them compatible. *Bioscience*, 49(4): 281-286.

Reiter, D. K., Brunson M. W., & Schmidt R. H. 1999. Public Attitudes toward Wildlife Damage Management and Policy. *Wildlife Society Bulletin*, 27(3): 746-758.

Richmond, Todd. 2013. "Humane societies appeal ruling that OK'd dogs for wolf hunt". Associate Press, (accessed April 16, 2013). http://www.twincities.com/politics/ci_23014645/wisconsin-humane-societies-appeal-ruling-that-okd-dogs

Ripple, W.J. and R.L. Bestcha. 2006. Linking wolves to willows via risk-sensitive foraging by ungulates in the northern Yellowstone ecosystem. *Forest ecology and management,* 230(1-3): 96-106.

Rutledge, L. Y. et al. 2010. Protection from Harvesting Restores Natural Social Structure in Eastern Wolf Packs. *Biological Conservation*, 143: 332-339.

Sarewitz, D. 2004. How Science makes environmental controversies worse. *Environmental Science and Policy*, 7: 385-403.

Sarewitz, D. *Science and Environmental Policy: An Excess of Objectivity*. In Frodeman, R. (Ed.), Earth Matters: The Earth Sciences, Philosophy, and the Claims of Community (pp. 79-98). 2000. Upper Saddle River, NJ: Prentice Hall.

Schanning, K. 2009. Human Dimensions: Public Opinion Research Concerning Wolves in the Great Lakes States of Michigan, Minnesota, and Wisconsin. In Wydeven A. P., van Deelen T. R., & Heske E. (Eds.), *Recovery of Gray Wolves in the Great Lakes Region of the United States: An Endangered Species Success Story* (pp 251-266). New York, NY: Springer.

Shackelford, J. 2007. Western Politics and Wildlife Policy: The Case of the Gray Wolf. *Sustainable Development Law & Policy*, 8(1): 44-45.

Shaffer, M. L. 1981, Feb. Minimum Population Sizes for Species Conservation. *BioScience*, 31(2): 131-134.

Shelley, V., A. Treves and L. Naughton. 2011. Attitudes to Wolves and Wolf Policy Among Ojibwe Tribal Members and Non-tribal Residents of Wisconsin's Wolf Range. *Human Dimensions of Wildlife*, 16(6): 397-413.

Sidorovich, V. E., Tikhomirova L. L., & Jedrzejeqska B. 2003. Wolf *Canis lupus* Numbers, Diet and Damage to livestock in relation to Hunting and Ungulate Abundance in Northeastern Belarus during 1990-2000. *Wildlife Biology*, 9(2): 103-111.

Smith, D., D. Stahler, E. Albers, R. McIntyre, M. Metz, J. Irving, R. Raymond, C. Anton, K. Cassidy-Quimby, and N. Bowersock, 2011. Yellowstone Wolf Project: Annual Report,

2010. YCR-2011-06. National Park Service, Yellowstone National Park, Yellowstone Center for Resources, Yellowstone National Park, Wyoming.

Smith, D. W. et al. 2010, May. Survival of Colonizing Wolves in the Northern Rocky Mountains of the United States, 1982–2004. *The Journal of Wildlife Management*, 74(4): 620-634.

Smith, M. E., Linnell J. D. C., Odden J., and Swenson J. E. 2000. Review of Methods to Reduce Livestock Depredation II. Aversive conditioning, deterrents and repellents. *Acta Agriculturae Scandinavica, Section A – Animal Science*, 50(4): 304-315.

Stahler, D.R., B. Heinrich and D.W. Smith. 2002. Common ravens, Corvus corax, preferentially associate with grey wolves, Canis lupus, as a foraging strategy in winter. *Animal Behaviour,* 64(2): 283.

Steel, B., List, P., Lach, D. and Shindler, B. 2004. The role of scientists in the environmental policy process: a case study from the American west. *Environmental Science and Policy*, 7: 1-13.

Thompson, J. G. 1993. Addressing the human dimensions of wolf reintroduction: An example using estimates of livestock depredation and costs of compensation. *Society & Natural Resources: An International Journal*, 6(2): 165-179.

Thurber, J. M. & Peterson, R. O. 1993. Effects of Populations Density and Pack Size on the Foraging Ecology of Gray Wolves. *Journal of Mammalogy*, 74(44): 879-889.

Treves, A. et al. 2004. Predicting Human-Carnivore Conflict: a Spatial Model Derived from 25 Years of Data on Wolf Predation on Livestock. *Conservation Biology*, 18(1): 114-125.

Tucker, P. & Pletscher, D. H. 1989. Attitudes of Hunters and Residents toward Wolves in Northwestern Montana. *Wildlife Society Bulletin*, 17(4): 509-514.

United States Fish and Wildlife Service, (accessed April 23, 2013). http://www.fws.gov/mountain-prairie/species/mammals/wolf/

Verdade, L. M. 1996. The Influence of Hunting Pressure on the Social Behavior of Vertebrates. *Rev. Brasil Biology*, 56(1): 1-13.

Walgamott, Andy. "Colville Tribes Holding Washington's First Wolf Hunt." Northwest Sportsman, December 4, 2012, (accessed February 13, 2013). http://www.nwsportsmanmag.com/2012/12/04/colville-tribes-holding-washingtons-first-wolf-hunt/

Wallach, A. D., Ritchie E. G., Read J., & O'Neill A. J. 2009. More than Mere Numbers: The Impact of Lethal Control on the Social Stability of Top-Order Predator. *PLoS ONE*, 4(9).

Washington Department of Fish and Wildlife. 2008. 2009-2015 Game Management Plan. Wildlife Program, Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Way, J. G., & Burskotter J. T. 2012. Additional Considerations for Gray Wolf Management after their removal from Endangered Species Act Protections. *The Journal of Wildlife Management*, 76(3): 457-461.

Webb, N., Merrill E., & Allen J. 2009. Density, Demography, and Functionality of a Harvested Wolf Population in West-Central Alberta, Canada. Wolf Management Summary, Alberta, Canada.

White, K. A., Lewis, M. A., & Murray, J. D. 1996. A Model for Wolf Pack Territory Formation and Maintenance. *Journal of Theoretical Biology*, 178: 29-43.

Wiles, G. J., Allen H. L., & Hayes G. E. 2011, Dec. Wolf Conservation and Management Plan for Washington. Washington Department of Fish and Wildlife, Olympia, Washington. 297 p.

Williams, C. K., Ericsson G., & Heberlein T. A. 2002. A Quantitative Summary of Attitudes towards Wolves and Their Reintroduction (1972-2000). *Wildlife Society Bulletin*, 30(2): 1-10.

Williams, R. "Tribes opposed to possibility of Michigan wolf hunting season." Michigan Radio: News for Michigan, November 13, 2012, (accessed February 13, 2013). http://www.michiganradio.org/post/tribes-opposed-possibility-michigan-wolf-hunting-season

Wilmar, C. C., and W. M. Getz. 2004. Simulating the Effects of Wolf-elk Population. *Science Direct*, 193-208.

Wilmar, C.C. and W.M. Getz . 2005. Gray wolves as climate change buffers in Yellowstone. *PLoS Biology,* 3: 571.

Wilson, P. I. 1999. Wolves, Politics, and the Nez Perce: Wolf Recovery in Central Idaho and the Role of Native Tribes. *Natural Resources Journal*, 39: 543-564.

Wolf Working Group, (accessed February 20, 2013). http://wdfw.wa.gov/conservation/gray_wolf/principles.html

Wuerthner, G. 2011. "Management of Predators: A need for change in policies." Report commissioned by Big Wildlife, May 2011.

York, R., Rosa, E. A., Dietz, T. 2002. Bridging Environmental Science with Environmental Policy: Plasticity of Population, Affluence, and Technology. *Social Science Quarterly*, 83(1): 18–34.

Appendix

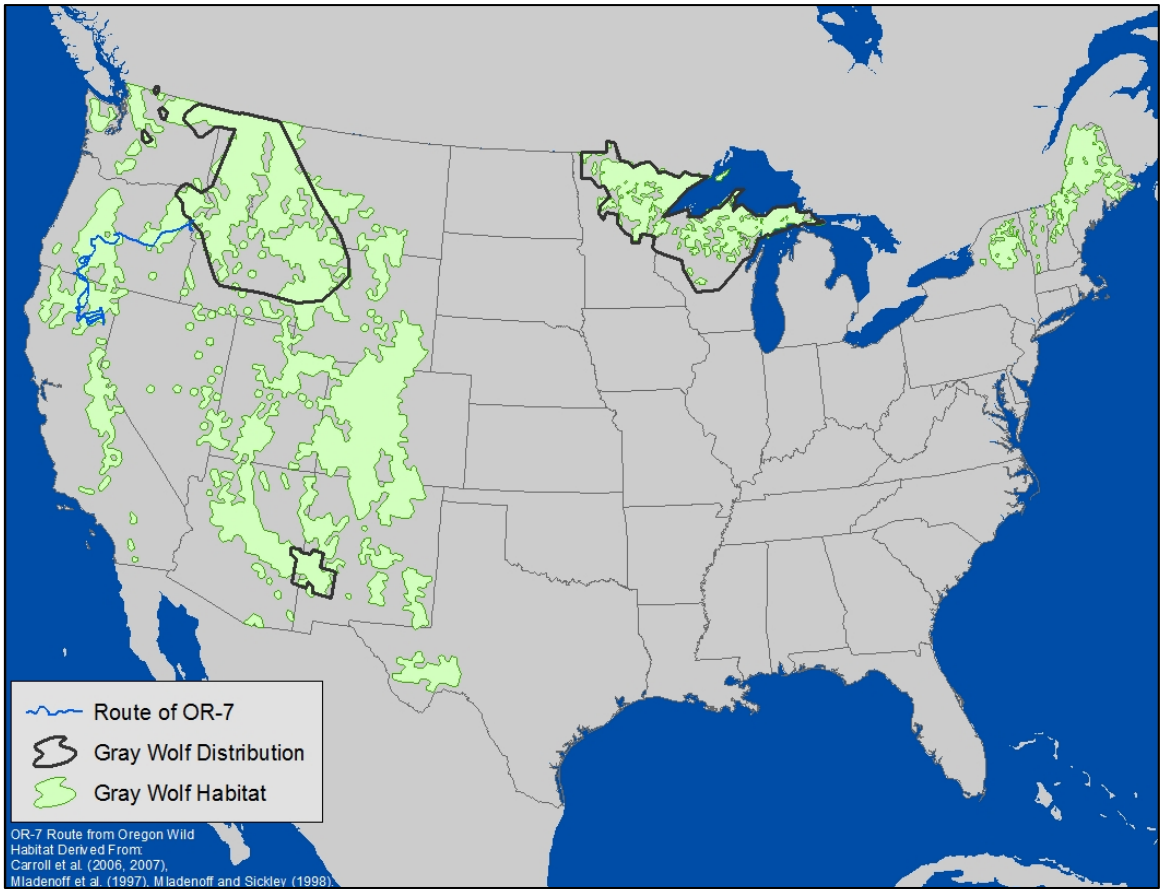

Figure 1 - Map of gray wolf habitat and distribution circa 2009, provided by USFWS website, accessed May 2013.

Appendix

Figure 2 - Northern Rocky Mountain gray wolf Distinct Population Segment boundaries established by the U.S. Fish and Wildlife Service in 2008 and 2009.

Appendix

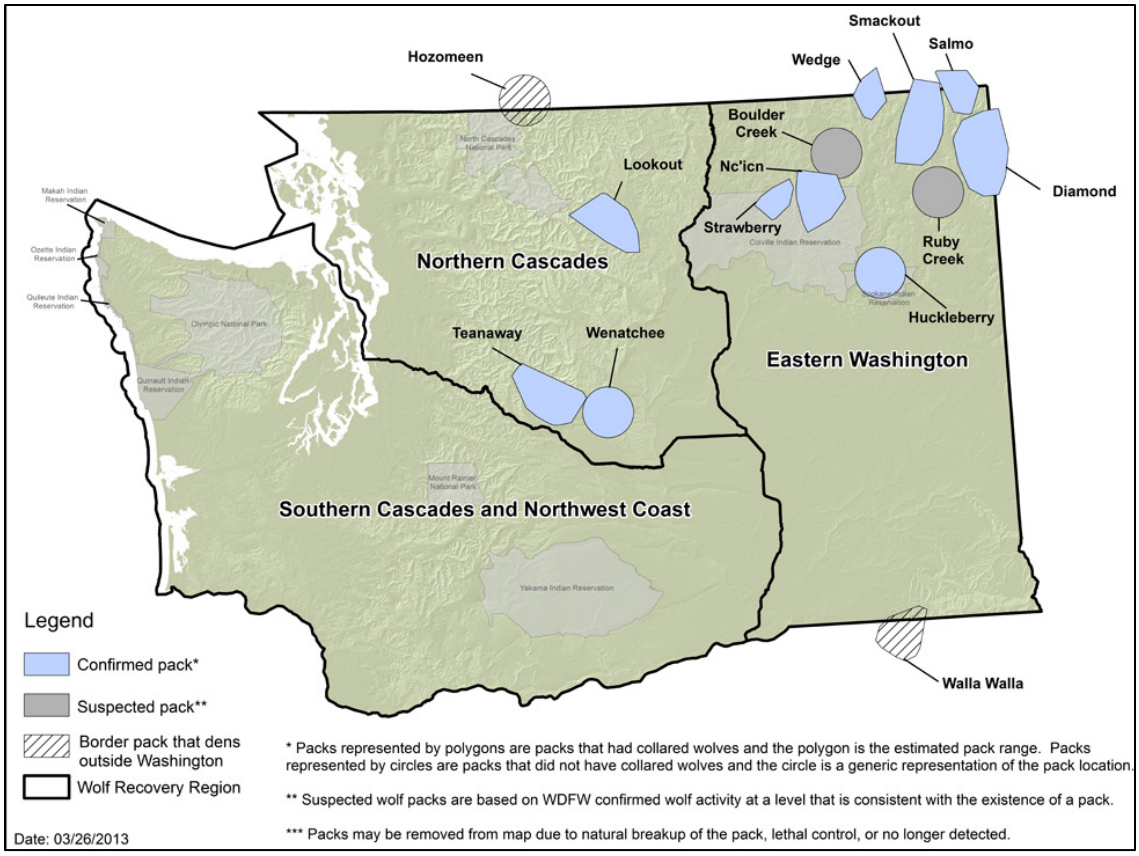

Figure 3 - Distribution of WA State wolf packs and designated recovery zones provided by the Washington Department of Fish and Wildlife, Mar. 2013

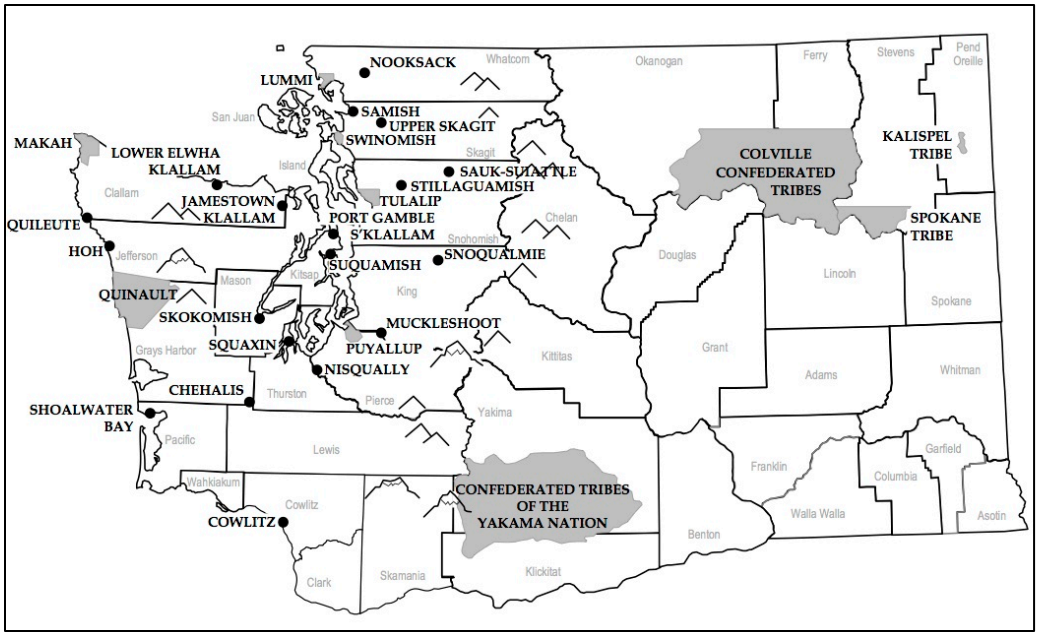

Figure 4 - Map of federally recognized tribes in WA State provided by the Governor's Office of Indian Affairs, May 2013.

Appendix

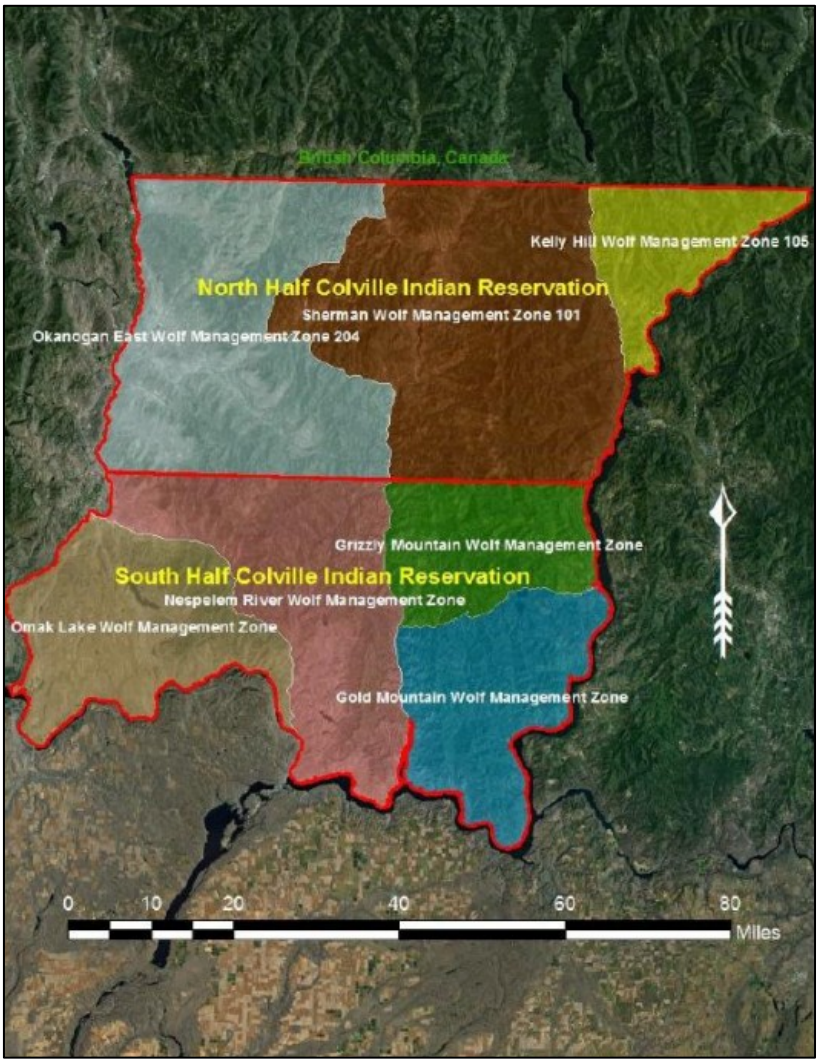

Figure 5 - Map of Colville Indian Reservation wolf recovery and hunting zones provided by Colville Indian Reservation website, April 2013.

Appendix

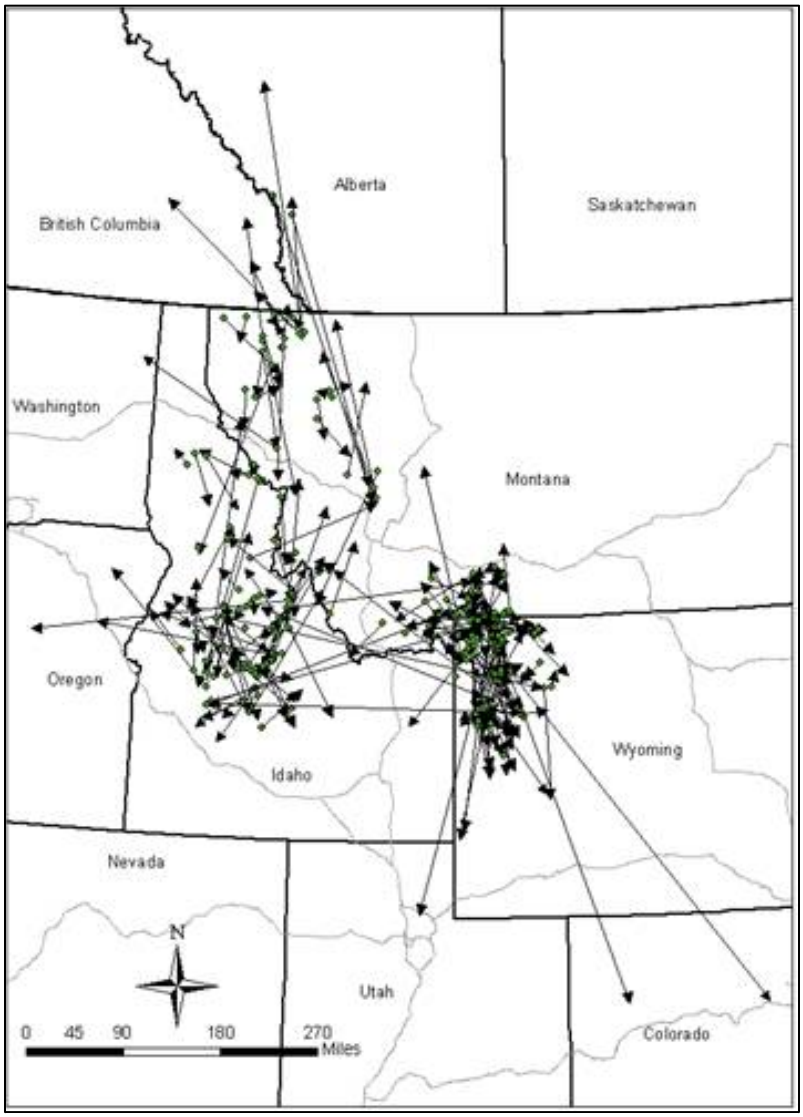

Figure 6 - Map of radio-collared wolf dispersal - NRM 1995-2008 provided by USFWS, accessed May 2013.