# JOB PROGRESS REPORT: **Category B - PROJECT #2**

# FEDERAL AID IN WILDLIFE RESTORATION

# WASHINGTON CARNIVORE RESEARCH

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**Job 1 Title:** Conduct radio-telemetry studies to investigate cougar and wolf interactions in wolf-occupied landscapes in Washington.

**Period Covered:** **01 July 2017 through 30 June 2018**

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## SUMMARY ACCOMPLISHMENTS

Between July 1, 2017 and June 30, 2018, we successfully captured 33 new cougars and outfitted 17 adult and subadult cougars with GPS radio collars. Twenty new cougars were captured in the Northeast study area with 10 adults and subadult outfitted with a GPS radio collar. Eleven new cougars were captured in the Okanogan with seven of these being adults and subadults that were collared. We also captured and collared four wolves from four packs in FY18 – a subadult female in Carpenter Ridge (NE), an adult female in Dirty Shirt (NE), an adult female in Loup Loup (Okanogan), and an adult female in Stranger (NE). We documented four mortalities of project cougars between July 1, 2017 and June 30, 2018. Specifically, we documented one mortality of an adult female in the Northeast study from likely exposure to feline distemper, one mortality of a subadult male in Idaho after it depredated on livestock, an adult female that was harvested by a licensed hunter in the Okanogan study area, and an adult male that was harvested by a licensed hunter accompanied by a guide in southern British Columbia, Canada. We visited 208 cougar clusters (Northeast: n = 112, Okanogan: n = 96) and documented 136 predation events (Northeast: n = 73, Okanogan: n = 63). Cougars largely preyed upon mule deer in the Okanogan study area, while white-tailed deer comprised the bulk of prey items in the Northeast. We visited 37 wolf clusters (Northeast: n = 32, Okanogan: n = 5) and documented 21 predation events (Northeast: n = 18, Okanogan: n = 3). Wolves primarily preyed upon moose in the Northeast and mule deer in the Okanogan. Our observations reported here represent the first 18 months of intensive field research into interactions between cougars and wolves in Washington's managed landscapes. Consequently, this report represents initial observations and no real inferences can be made. However, previous investigations of cougar-

wolf interactions focused primarily on the partitioning of space and prey in areas with a reduced human presence (e.g., Ruth et al. 2015), limiting their value to wildlife managers working in landscapes where people exert considerable influence. Our investigation represents the first attempt to quantify the interplay and impacts of wolves and people on a cougar populations and foraging ecology in a managed landscape.

## INTRODUCTION

Grey wolf (*Canis lupus*) recolonization can have significant ecological and cultural ramifications (citations). The reemergence of Washington's grey wolf population has the potential to alter ecosystem form and function through the direct and indirect effects of predation on ungulate prey and competition with sympatric carnivores (Creel et al. 2005; Kittle et al. 2008; Atwood et al. 2009; Elbroch et al. 2015; Merkle et al. 2017). While these effects may be ecologically beneficial (Ripple et al. 2005; Painter et al. 2015; Beschta et al. 2016), they can also be controversial if ungulate behavior and population size changes in ways that reduce recreational hunting and viewing opportunities (Kellert et al. 1996; Boertje et al. 2010; Berry et al. 2016). Accordingly, research on the effects of established and recolonizing wolf populations has largely focused on the relative importance of predation in shaping ungulate population dynamics (Meyer et al. 2008; Griffin et al. 2011; Brodie et al. 2013; Proffitt et al. 2014). In Washington, the impacts of a recolonizing wolf population on deer (*Odocoileus* spp.), elk (*Cervus canadensis*), and moose (*Alces alces*) populations are not well understood, but likely mitigated or mediated by the effects of alternative prey, sympatric large carnivores, habitat quality, abiotic factors, and people (Washington Department of Fish and Wildlife 2016a). Consequently, understanding the impacts of wolves on their ungulate prey requires a greater understanding of systems as a whole, including the predator-prey dynamics of, and relationships within, communities consisting of multiple large carnivores and people.

Interspecific competition among sympatric carnivores plays a critical role in the predator-prey dynamics of communities (Durant 1998; Vanak et al. 2013; Abrams and Cortez 2015; Chan et al. 2017). Direct and indirect interactions influence not only the space use patterns and foraging ecology of individual species (i.e., who is eaten by whom and where; Thaker et al. 2011; Allen et al. 2014; Elbroch et al. 2015), but the overall flow of energy within a system (Wilmers et al. 2003, Moleón et al. 2014). Competition in the form of displacement, kleptoparasitism, and interspecific killing can increase individual kill rates (Elbroch et al. 2015, Tallian et al. 2017), reduce fitness (Periquet et al. 2015), and suppress the populations of subordinate carnivores (Creel 2001; Levi and Wilmers 2012; Allen et al. 2015). These changes have the potential to alter the risk landscapes and population characteristics for ungulate prey (Thaker et al. 2011, Vanak et al. 2013) and complicate efforts by wildlife managers to meet population objectives.

The cougar (*Puma concolor*) and the wolf are apex predators that compete for space and large, ungulate prey in landscapes where they co-occur (Husseman et al. 2003, Ruth and Murphy 2010a). The cougar is typically considered a subordinate competitor to the wolf (Ruth and Murphy 2010b; Lendrum et al. 2014; Elbroch et al. 2015), but divergent hunting strategies allow for partitioning of both space (Ruth et al. 2011) and resources (Kunkel et al. 1999) that helps to reduce competition between the two species. The cougar employs a stalk and pounce hunting strategy that is advantageous for targeting prey opportunistically in landscapes with rugged, structurally complex terrain (Husseman et al. 2003; Atwood et al. 2007; Ruth and Murphy 2010b), whereas wolves are a social, coursing predator better suited to select and pursue disadvantaged prey in open, gentle terrain over an extended hunt (Husseman et al. 2003, Peterson et al. 2003). Even with these divergent foraging strategies, wolves are capable of altering the space use, foraging ecology, and realized niche of cougars (Bartnick et al. 2013, Elbroch et al. 2015). Additionally, interspecific killing of cougars by wolves and wolves by cougars is well documented (Kortello et al. 2007; Jimenez et al. 2008; Elbroch et al. 2015; Ruth et al. 2015; Washington Department of Fish and Wildlife, unpublished data) and provides direct evidence of interference competition between the species. Quantifying the impacts of a growing wolf population on cougar population characteristics and social organization and in turn, management of cougar populations and associated predator-prey relationships, represents a logical, and necessary next step.

Previous investigations of cougar-wolf relationships were primarily undertaken in landscapes with a minimal human footprint (i.e., wilderness areas and National Parks), limiting their value to managers working in systems with an extensive human presence. Anthropogenic impacts on carnivore populations are substantial and pervasive (Sunquist and Sunquist 2001, Ripple et al. 2014). For cougars and wolves, humans can significantly limit the size and distribution of populations through recreational harvest (Lambert et al. 2006; Cooley et al. 2009; Robinson et al. 2014; Ausband et al. 2015), management removals (Bodenchuk 2011; Hurley et al. 2011; National Research Council 1997), landscape conversion (Beier et al. 2009; Burdett et al. 2010, Haskell et al. 2013) and increased exposure to variety of anthropogenic mortality sources (Murray et al. 2010; Smith et al. 2010; Thompson et al. 2014; B. Kertson, unpublished data). Excessive recreational harvest or management removals also have the potential to alter the composition and function of cougar and wolf populations (Beausoleil et al. 2013, Ausband et al. 2017). For example, excessive anthropogenic mortality reduces the number and presence of dominant, territorial males contributing to a breakdown of cougar social organization (Beausoleil et al. 2013) and a subsequent increase in the preponderance of transients in the population (Kertson et al. 2013), increased male home range size and overlap (Maletzke et al. 2014), and increased rates of infanticide (Cooley et al. 2009). Given these strong top-down effects, humans are likely capable of directly modifying competition between cougars and wolves with impacts on ungulate prey resulting accordingly.

Human activities may indirectly alter competition between cougars and wolves in complex, interdependent ways. Specifically, cougars are well adapted for wildland-urban landscapes and they routinely exploit suitable habitat and resources within residential areas (Beier et al. 2009; Kertson et al. 2011, 2013; Knopff et al. 2014; Smith et al. 2015). Conversely, the conspicuous foraging behavior and social dynamics of wolves are less advantageous in these environments and observations to date indicate wolf use of residential areas and associated prey occurs less frequently (Heilhecker et al. 2007, Kojola et al. 2016). If cougars increase their use of residential areas to reduce competition with wolves, they would also increase their potential for interactions with people and risk of mortality (Kertson et al. 2013). Under this scenario, residential areas would appear to offer competition refugia for cougars, but actually represent an attractive sink. An alternative, and potentially more advantageous strategy would have cougars minimizing the risks associated with greater proximity to wolves and people by concentrating their space use at the wildland-urban interface (i.e., the Goldilocks strategy).

To better understand the impacts and interplay of wolves and people on cougars, we examined cougar population characteristics, foraging behavior, and spatial ecology in Washington's wolf-occupied landscapes. Our research was carried out as one component of a large, multi-species examination of wolf impacts on predator-prey relationships in Washington and our research findings will be used in part to meet relevant cougar, wolf, and predator-prey management objectives outlined in the 2015-2021 WDFW Game Management Plan (Washington Dept. of Fish and Wildlife 2015). This report provides detailed descriptions of our research accomplishments between July 1, 2016 and June 30, 2017.

## STUDY AREA

We investigated the relative impacts of wolves and people on cougar population characteristics in two distinct study areas located in eastern Washington (Fig. 1).

### *Northeast*

The Northeast study area is centered on the town of Chewelah encompassing 4,527 $km^2$ of Stevens and Pend Oreille counties, Washington (11U 446800 E, 5347784 N; Fig.1). The project area is bisected by State Highway 395 into western and eastern sections; effectively creating roughly equivalent western and eastern halves. Land ownership in the project area is a composite of federal, state, municipal, and private holdings managed for timber production, multiple-use, commercial use, agriculture, wildlife conservation, and private residences. Major landowners include the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service, Bureau of Land Management (BLM), Washington Department of Natural Resources (WADNR), Hancock

Resource Management Group, Arden Tree Farms, Inland Empire Paper, and Stimson Lumber. Residential development is concentrated along the Washington State Highway 395, U.S. Highway 2, and U.S. Highway 20 corridors with exurban and rural development extending into the foothills and mountains beyond the highway corridors. The project area consists of WDFW Game Management Units 117 (49 Degrees North) and 121 (Huckleberry). Cougar recreational harvest levels consistently reach WDFW harvest thresholds established for these GMUs with additional cougars frequently removed following interactions with people (Washington Department of Fish and Wildlife 2016).

The Northeast study area is part of the Okanogan Highlands physiographic province, a glacially subdued mountainous region occupying the transitional zone between the eastern slope of the Cascade Mountains and northern Rocky Mountains (Bailey et al. 1994). The study area is characterized by mixed conifer forests of varying seral stages arrayed along climatic and topographic gradients of the southern Selkirk and Huckleberry Mountains (Williams et al. 1995). Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) forest associations dominate dry, low elevation sites and south facing slopes while western hemlock (*Tsuga heterophylla*)/western red cedar (*Thuja plicata*) forests dominate mesic areas and north facing slopes. High elevation sites (>1,300 m) are dominated by subalpine fir (*Abies lasiocarpa*) forest associations (Williams et el. 1995). Tree species present include ponderosa pine, Douglas-fir, western red cedar, western hemlock, grand fir (*Abies grandis*), western larch (*Larix occidentalis*), subalpine fir, western white pine (*Pinus monticola*), black cottonwood (*Populas trichocarpa*), and quaking aspen (*Populas tremuloides*). Elevations range from 391 to 2088 m and the climate has both maritime and continental characteristics. Mean annual temperatures in Chewelah range from -3.9° C in January to 19.5° C in July with a mean annual precipitation level of 52.3 cm (Western Regional Climate Center 2017).

Northeast Washington represents an established wolf population and consists of a minimum of 80 wolves and 15 known wolf packs. Four known wolf packs (Stranger, Huckleberry, Dirty Shirt, and Carpenter Ridge) and a minimum of 27 wolves reside within the Northeast study area (Washington Department of Fish and Wildlife 2016). Other carnivores inhabiting the Northeast study area that may compete with cougars include bobcat (*Lynx rufus*), coyote (*Canis latrans*), and black bear (*Ursus americana*). Potential prey includes white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), moose (*Alces alces*), snowshoe hare (*Lepus americanus*), porcupine (*Erethizon dorsatum*), beaver (*Castor canadensis*), coyote, raccoon (*Procyon lotor*), ruffed grouse (*Bonasa umbellus*), dusky grouse (*Dendragapus obscurus*), and turkey (*Meleagris gallopavo*).

*Okanogan*

The Okanogan study area is centered on the town of Winthrop encompassing 5,297 $km^2$ of Okanogan county, Washington (10U 707963 E, 5373251 N; Fig.1). Land ownership in the project area is a composite of federal, state, and private holdings managed for timber production, multiple-use, wilderness, wildlife conservation, agriculture, and private residences with the majority of lands managed by the USFS and WDFW. Residential development is largely concentrated within valley bottoms along the U.S. Highway 20 and State Highway 153 corridors with scattered exurban and rural development present throughout the Methow, Chewuch, and Twisp river drainages. The project area consists of WDFW Game Management Units 218 (Chewuch), 224 (Pearrygin), 231 (Gardner), 239 (Chiliwist) and 242 (Alta). Cougar recreational harvest levels with the Okanogan study area frequently reach management thresholds but vary considerably both amongst GMUs and from year to year driven in large part by snow conditions and access (Washington Department of Fish and Wildlife 2016).

The Okanogan study area lies within the North Cascade Range, a topographically rugged and mountainous region consisting of deep, U-shaped valleys and steep slopes formed by alpine glaciation (Williams et al. 1983). Ponderosa pine and Douglas fir forests dominate wide drainage bottoms and south-facing slopes below 1,066 m in elevation while subalpine fir and Engelmann spruce forest dominate higher elevations, steep, narrow drainages, and north-facing aspects at lower elevations (Williams et al. 1983, Maletzke et al. 2008). Tree species include ponderosa pine, Douglas-fir, western red cedar, mountain hemlock (*Tsuga mertensiana*), lodgepole pine (*Pinus contorta*), whitebark pine (*Pinus albicaulis*), western larch, subalpine fir, Engelmann spruce, black cottonwood, and quaking aspen. Elevations range from 218 to 2720 m and the climate has both maritime and continental characteristics. Mean annual temperatures in Winthrop range -6.6° C in January to 20.0° C in July with a mean annual precipitation level of 31.4 cm (Western Regional Climate Center 2017).

The North Cascades represents a re-colonizing wolf population with a minimum population of 16 wolves and 3 known wolf packs. Two known wolf packs (Lookout and Loup Loup) and a minimum of 11 wolves reside within the Okanogan study area (Washington Department of Fish and Wildlife 2016). Other carnivores inhabiting the Okanogan study area that may compete with cougars include bobcat, lynx (*Lynx canadensis*), coyote, and black bear. Potential prey includes mule deer, white-tailed deer, moose, snowshoe hare, porcupine, beaver, coyote, raccoon, ruffed grouse, dusky grouse, and turkey.

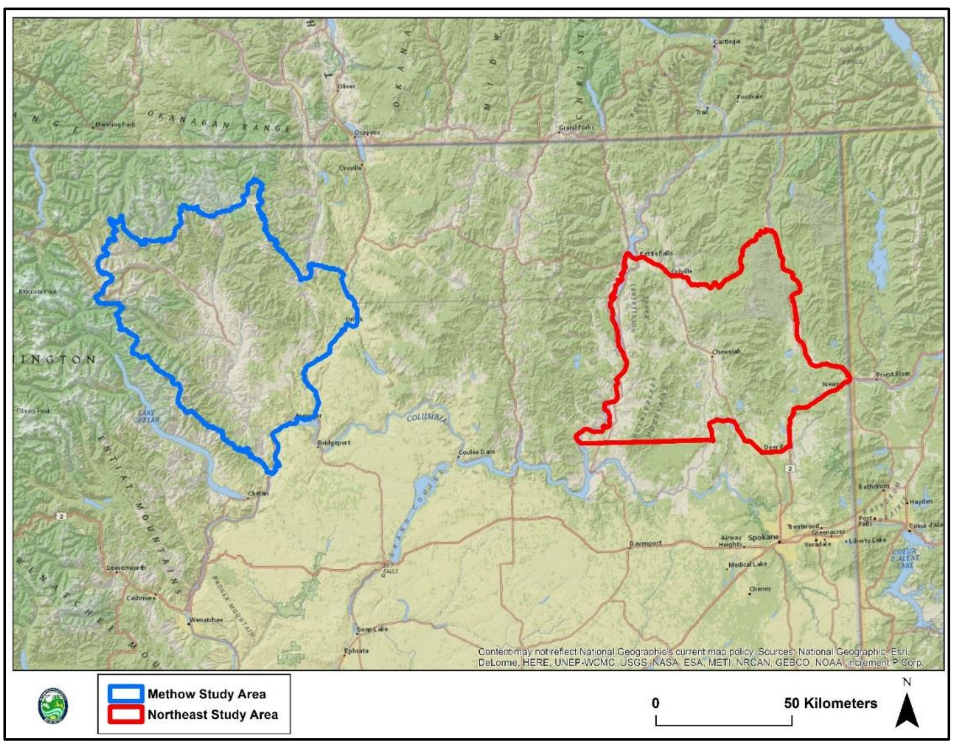


**Figure 1:** Location and boundaries of the 4,527 km$^2$ Northeast and 5,297 km$^2$ Okanogan study areas centered on the towns of Chewelah and Winthrop, Washington, USA.

**METHODS**

*Capture, Collaring, and Monitoring*

We captured adult and subadult cougars within each study area using a combination of trained dogs and steel cage traps (Kertson et al 2011a, b). Cougars were immobilized using a 10:1 mixture of ketamine hydrochloride and xylazine hydrochloride (ZooPharm, Windsor, Colorado, USA) administered intramuscularly at a dosage of 8.8 mg/kg ketamine and 0.88 mg/kg xylazine via a 3.0 ml plastic dart fired from a $CO^2$ powered dart gun (Dan-Inject Dart Guns, Austin, Texas, USA; Kertson et al. 2011a,b). Immobilized cougars were given a physical examination, sexed, ear-tagged, aged via dental characteristics (Laundre et al. 2000, Anderson and Aune 2004), and classified as a kitten (< 12 months of age), subadult (12-30 months of age), or adult (> 30 months of age; Spreadbury et al. 1996; Logan and Sweanor 2001; Kertson et al. 2013).

We captured wolves in each pack residing within the study area using a combination of foothold traps (Model EZ Grip Size 7, Livestock Protection Company, Alpine, Texas, USA) and aerial darting. Wolves were immobilized using a mixture of tiletamine hydrochloride and zolazepam hydrochloride (Telazol, Zoetis, Parsippany, New Jersey, USA) administered intramuscularly at a dosage of 7.0 mg/kg via a jab stick (trapping) or dart gun (aerial captures; Smith et al. 2010). Immobilized wolves were given a physical examination, sexed, ear-tagged, aged via dental characteristics (Landon et al. 1998, Gipson and Ballard 2000), and classified as a pup (< 12 months of age), yearling (12-24 months of age), or adult (> 24 months of age).

We outfitted adult and subadult cougars and adult and yearling wolves with a mortality-sensing 550 g Global Positioning System (GPS) radio collar with an Iridium satellite uplink (Model Vertex Lite, Vectronics Aerospace, Berlin, Germany). Kittens 4-6 weeks of age were captured, ear tagged, and outfitted with expanding Vhf radio collar at the den using the methodology of Cooley et al. (2009) and monitored a minimum of once per month. Global Positioning System radio collars were programmed to attempt a satellite fix every 4 hrs for 180 s and location data will be relayed daily via the Iridium uplink.

All cougar and wolf captures and handling were performed in accordance with guidelines of the American Society of Mammalogists for the use of wild mammals in research (Sikes et al. 2011) and the University of Washington Institutional Animal Care and Use Committee.

*Survival*

We used a combination of GPS relocation data, mortality alerts relayed via the Iridium satellite uplink, and ground-based radio telemetry to monitor cougar status (i.e., alive/dead). We investigated suspected mortalities as soon as possible and performed field necropsies to determine the cause of death. When the mortality source could not be readily identified from the necropsy, we collected blood, tissue and other biological samples for additional analyses and cause of death determination by a veterinary pathologist (Northwest ZooPath, Monroe, Washington).

*Kill Site Analysis*

To better understand the impacts of wolf recolonization on cougar foraging ecology, we visited suspect cougar predation events identified from clusters of relocations provided by GPS radio collars (Knopff et al. 2009). Relocations were plotted in ArcMap 10.2 (Environmental Systems Research Institute, Redlands, CA, USA) and examined sequentially using a modified version of the Python script developed by Knopff et al. (2009) to identify potential clusters (White and others 2011). To minimize the likelihood of visiting sites not related to predation events, we modified the criteria of Anderson and Lindzey (2003) and defined a cluster as four or more relocations within 150 meters within a 96-hour period, or two relocations within 100 meters within a 96-hour period. When a cluster was identified, we attempted to investigate as soon as possible to maximize the chance of locating prey remains. We approximated the geometric center of the each cluster on a topographic map and loaded the Universal Transverse Mercator (UTM) coordinates into a handheld GPS receiver to navigate to the site in the field (White and others 2011). We searched for prey remains by walking approximately 5-m concentric circles from the target coordinates and traveling wildlife trails located in the immediate vicinity (within 40 m) of the location until prey remains were located (White et al. 2011, Blake and Gese 2016). When necessary, we visited individual GPS locations within the cluster and searched for the presence of a carcass, hair pile, kill site, or other evidence of scavenging/predation. For clusters containing ungulate prey, we recorded species, sex, and age. In cases where species and/or sex could not be determined due to degradation of the carcass we collected a DNA sample consisting of hair and tissue from the hide. We estimated age from mandible tooth eruption and wear and when available, a middle incisor was collected for additional age determination.

## RESULTS

### *Captures and Monitoring*

We successfully captured 33 new cougars and outfitted 17 adult and subadult cougars with GPS radio collars between July 1, 2017 and June 30, 2018. Twenty new cougars were captured in the Northeast study area with 10 adults and subadult outfitted with a GPS radio collar. Eleven new cougars were captured in the Okanogan with seven of these being adults and subadults that were collared. To date, we have captured 49 cougars and collared 33 adults and subadults. Twenty nine cougars have been captured and 17 collared in the Northeast study area while 20 cougars were captured in the Okanogan with 16 outfitted with GPS radio collars. Between June 1, 2017 and July 30, 2018, we monitored 14 collared cougars in the Northeast study area for 14 – 365 days and 11 collared cougars in the Okanogan study area for 114-365 days. We also captured and collared four wolves from four packs in FY18 – a subadult female in Carpenter Ridge (NE), an adult female in Dirty Shirt (NE), an adult female in Loup Loup (Okanogan), and an adult female in Stranger (NE). Collared wolves were monitored in FY18 for 141 – 200 days in NE Washington and 143 days in the Okanogan.

We documented three GPS collar malfunctions in FY18 that impacted monitoring and data acquisition. Cougar NC107F's collar malfunctioned on January 31, 2018 and was replaced on March 21, 2018 while cougar NC114F's collar malfunctioned 14 days after her capture and her status was unknown on June 30, 2018. Wolf 074M (Carpenter Ridge) experienced a collar malfunction on January 16, 2018, likely brought about by a broken battery cable. The status of the wolf on June 30, 2018 was unknown.

*Survival*

We documented four mortalities of project cougars between July 1, 2017 and June 30, 2018. Specifically, we documented one mortality of an adult female in the Northeast study from likely exposure to feline distemper, one mortality of a subadult male in Idaho after it depredated on livestock, an adult female that was harvested by a licensed hunter in the Okanogan study area, and an adult male that was harvested by a licensed hunter accompanied by a guide in southern British Columbia, Canada. To date, we have documented 10 mortalities of project animals with the majority of these stemming directly or indirectly from anthropogenic sources (Table 1). Two male cougars (one subadult, one adult) were killed following livestock depredation events (both Northeast), one subadult female died of malnutrition (Okanogan), one adult male was legally harvested (Okanogan), one subadult female was killed by another cougar (Northeast), and one adult male died of unknown causes.

**Table 1:** Summary of the number of documented mortalities of cougars captured in the Northeast and Okanogan study areas between December 1, 2016 and June 30, 2018.

| | **Mortality Source** | | | | |
|---|---|---|---|---|---|
| | Harvest | Conflict | Instraspecific Strife | Disease | Malnutrition |
| Northeast | | 3[a] | 1 | 1 | |
| Okanogan | 3[b] | | 1 | | 1 |

**a** Total includes a subadult male that dispersed to north Idaho and was killed for depredating on domestic sheep.
b Total includes an adult male that was killed during a guided cougar hunt in southern British Columbia, Canada.

*Reproduction*

Between July 1, 2017 and June 30, 2018, I documented seven litters consisting of 17 kittens ($\overline{x}$ =2.4 kittens/litter, SD =1.0) with an overall sex ratio of approximately 1:1 (n = 9 females, n = 8 males). Three of the seven litters were born during the summer months (June, July, August, or September) with the remaining litters born during winter or spring months (February: n =1; March = 1, May: n =2). Den visits, track surveys, and camera traps yielded a mean annual maternity rate of 1.0 kittens/adult female (SD = 1.0, n = 7) in the Northeast study area in biological year 2017.

*Kill Site Analysis*

Between July 1, 2017 and June 30, 2018, we visited 208 cougar clusters (Northeast: n = 112, Okanogan: n = 96) and documented 136 predation events (Northeast: n = 73, Okanogan: n = 63). Cougars largely preyed upon deer in the Northeast study area and mule deer in the Okanogan (Table 2). We visited 37 wolf clusters (Northeast: n = 32, Okanogan: n = 5) and documented 21 predation events (Northeast: n = 18, Okanogan: n = 3). Wolves primarily preyed upon moose in the Northeast and mule deer in the Okanogan (Table 3). To date, we have visited 267 cougar clusters (Northeast: n = 137, Okanogan: n = 130) and documented 177 predation events (Okanogan: n =87; Northeast: n =90). Cougars largely preyed upon deer in both study areas with white-tailed deer comprising the majority of prey items documented in the Northeast study area and mule deer in the Okanogan study area (Table 4).

**Table 2:** Summary of cougar prey species and number of kills (n = 136) identified from cluster site investigations in the Northeast and Okanogan study areas between July 1, 2017 and June 30, 2018.

| | Mule deer | White-tail deer | Unk deer spp. | Elk | Grouse spp. | Porcupine | Snowshoe hares | Avian spp. |
|---|---|---|---|---|---|---|---|---|
| Northeast | 5 | 31 | 32 | 2 | 1 | 1 | | 1 |
| Okanogan | 38 | 2 | 19 | | 1 | | 2 | 1 |

**Table 3:** Summary of wolf prey species and number of kills (n =22) identified from cluster site investigations in the Northeast and Okanogan study areas between July 1, 2017 and June 30, 2018.

| | Mule deer | Unk deer spp. | Elk | Moose |
|---|---|---|---|---|
| Northeast | 1 | 7 | 1 | 9 |
| Okanogan | 3 | | | 1 |

**Table 4:** Summary of cougar prey species and number of kills (n =177) identified from cluster site investigations in the Northeast and Okanogan study areas between December 1, 2016 and June 30, 2018.

| | Mule deer | White-tail deer | Unk deer spp. | Elk | Beaver | Grouse spp. | Porcupine | Snowshoe hares | Avian spp. |
|---|---|---|---|---|---|---|---|---|---|
| Northeast | 6 | 36 | 41 | 4 | | 1 | 1 | | 1 |
| Okanogan | 55 | 4 | 22 | | 1 | 2 | | 2 | 1 |

Twenty two cameras were deployed to monitor interspecific interactions and scavenging activity in both study areas between July 1, 2017 and June 30, 2018. Fourteen cameras were deployed on cougar kills (Northeast = 10, Okanogan = 4) and eight cameras deployed on ungulate mortalities (Northeast = 5, Okanogan = 3).

## DISCUSSION

Observations reported here represent the first 18 months of intensive field research into interactions between cougars and wolves in Washington's wolf-occupied landscapes. Consequently, this report represents initial observations and no real inferences can be made. However, previous investigations of cougar-wolf interactions focused primarily on the partitioning of space and prey in areas with a reduced human presence (e.g., Ruth et al. 2015), limiting their value to wildlife managers working in landscapes where people exert considerable influence. Our investigation represents the first attempt to quantify the interplay and impacts of wolves and people on a cougar populations and foraging ecology in a managed landscape.

Consequently, our research findings will aid wildlife managers in their understanding of community dynamics and predator-prey relationships by elucidating how humans mitigate or facilitate competition between apex predators and the subsequent impacts of this competition on the composition, behavior, and trajectory of the cougar population. Our research also represents one component of a large, multi-faceted collaborative research effort examining predator-prey dynamics in complex systems, so information on cougar populations will provided much needed context for understanding the impacts of cougar predation on ungulate prey (Objective 3; Washington Department of Fish and Wildlife 2015).

Beyond the context of cougar-wolf dynamics and predator-prey relationships, our research provides the added benefit of assisting WDFW meet their general cougar management objectives of maintaining viable populations, minimizing threats to public safety and private property, providing for a sustainable yield, and meeting a variety of recreational, educational, and aesthetic purposes (Washington Dept. of Fish and Wildlife 2015). Our investigation will also help to determine if the current WDFW harvest strategy achieves a stable population and maintains cougar social organization (Objective 92; Washington Dept. of Fish and Wildlife 2015) in northeast Washington.

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